Selection & Use of Materials, Components & Finishes in Engineering Design

Engineering Materials and Design

UNIVERSITY OF MICHIGAN
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ENGINEERING

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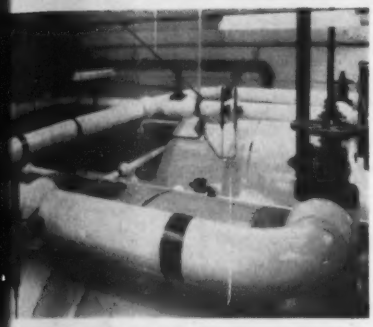

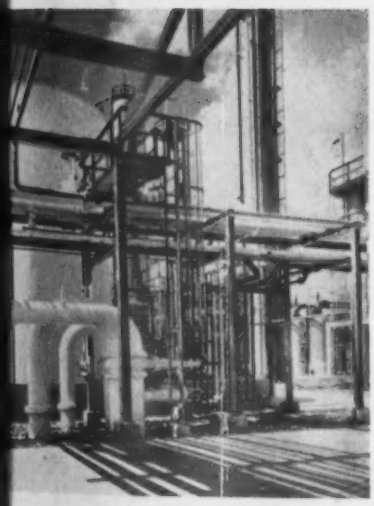

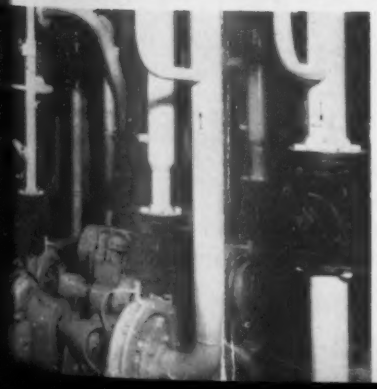

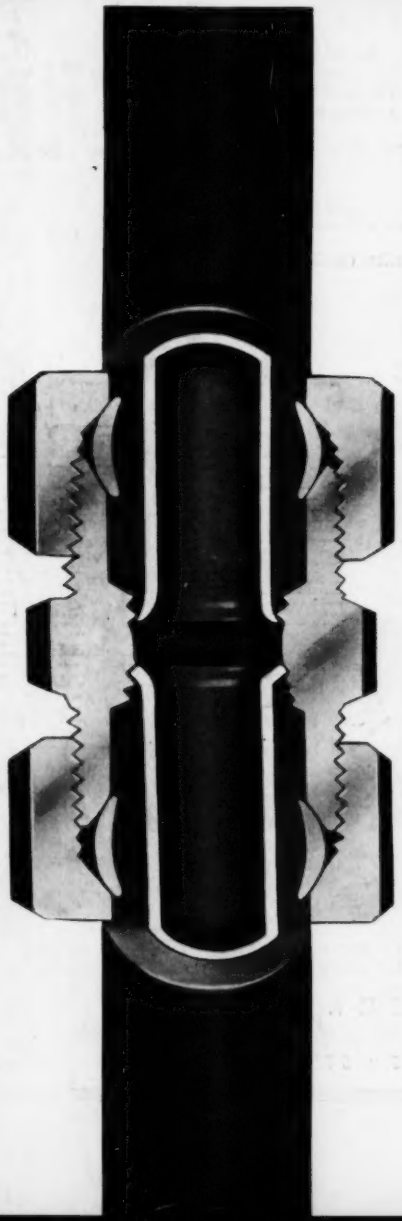

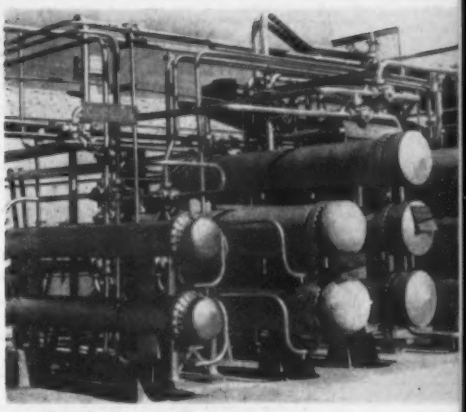

Pipe Couplings

page 514

EMD 7054 for further information

A New Tool Steel

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Vol. 4 No. 8 August 1961

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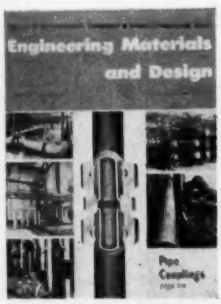

Section view of a Polystantor coupling (Yorkshire Imperial Metals Ltd.) used to connect plastics pipes. The background illustrations are by courtesy of: Chemical & Insulating Co. Ltd.; Girdlestone Pumps Ltd.; and Shell Chemical Co.

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ISSUE AT A GLANCE

page

MoS_2 ENHANCES WEAR RESISTANCE OF NYLON **502**
Description of how controlled amounts of molybdenum disulphide homogeneously dispersed in nylon allow parts to be produced at competitive cost.
By P. D. Mitchell

DESIGNING WITH THERMOPLASTICS **507**
Showing how engineering design techniques can be used to obtain optimum performance.
By R. L. Miller

SURVEY OF PIPE COUPLINGS: PART 1 ... ... **514**
Typical uses and limitations are described.
By A. H. Roach

GRAVITY DIECASTING IN ALUMINIUM BRONZE **526**
Stage by stage explanation of production in a foundry specialising in this class of work.
By F. W. Firth

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New Editor for E.M. & D. facing **498**
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Résumes

ETUDE DES RACCORDS DE TUYAUX: 1ème partie

par A. H. Roach page 514

L'auteur décrit diverses formes de raccord ainsi que leurs applications typiques et leurs limites. Il donne également une liste des types disponibles.

MoS_2 AUGMENTE LA RESISTANCE DU NYLON A L'USURE

par P. Mitchell page 502

Description d'une méthode permettant, en dispersant de façon homogène des quantités soigneusement contrôlées de bisulfure de molybdène dans le nylon, d'obtenir des sections résistant mieux à l'usure à des prix concurrentiels.

DESSIN AVEC MATIERES THERMOPLASTIQUES

par R. L. Miller page 507

L'article décrit comment on peut appliquer efficacement les techniques du dessin industriel aux matières thermoplastiques, dont on a soigneusement déterminé les propriétés physiques et qui ressemblent aux métaux non-ferreux, pour obtenir la meilleure performance a des frais réduits.

MATRICAGE DU BRONZE ALUMINIUM PAR PESANTEUR

par F. W. Firth page 526

L'auteur explique, point par point, la production de moules matricés de bronze aluminium dans une fonderie se spécialisant dans ce genre de travail. Il indique également le type de pièces que l'on peut produire ainsi.

Kurzreferate

ÜBERSICHT ÜBER ROHRVERBINDUNGEN: Teil I

A. H. Roach Seite 514

Der Artikel beschreibt verschiedene Arten von Verbindungen, ihre charakteristischen Verwendungen und Grenzen, und bringt eine Liste der verfügbaren Typen.

BESSERE VERSCHLEISSFESTIGKEIT VON NYLON DURCH MoS_2

P. Mitchell Seite 502

Eine Beschreibung, wie genau geregelte Mengen von Molybdän-disulfid, die gleichförmig im Nylon verteilt sind, den daraus erzeugten Teilen bei konkurrenzfähigen Kosten eine bessere Verschleissfähigkeit verleihen.

KONSTRUKTIONEN MIT THERMOPLASTEN

R. L. Miller Seite 507

Der Artikel zeigt wie Thermoplaste, deren Festigkeitseigenschaften genau bekannt sind und denen der NE-Metalle nahe kommen, wirksam im Maschinenbau verwendet werden können um beste Leistung mit niedrigeren Erzeugungskosten zu verbinden.

SCHWERKRAFT-SPRITZGUSS AUS ALUMINIUMBRONZE

F. W. Firth Seite 526

Der Verfasser erklärt Schritt für Schritt die Herstellung von Spritzgussstücken aus Aluminiumbronze in einer Spezialgiesserei und zeigt auch die Arten der Teile, die sich auf diese Art und Weise herstellen lassen.

Резюме

ОБЗОР ТРУБОПРОВОДНЫХ СОЕДИНЕНИЙ: Часть 1-ая

А. Х. Роч Стр. 514

Описываются различные виды соединения и их обычные применения и ограничения. Приводится список имеющихся типов.

ДИСУЛЬФИД МОЛИБДЕНА ПОВЫШАЕТ ИЗНОСОУПОРНОСТЬ НАЙЛОНА

П. Д. Мичелл Стр. 502

Описывается как контролированные количества дисульфида молибдена, гомогенно рассеянные в найлоне, делают возможным производство компонентов с лучшей износоупорностью, при способной выдержать конкуренцию стоимости.

КОНСТРУКЦИЯ С ТЕРМОПЛАСТАМИ

Р. Л. Миллер Стр. 507

В статье указывается, как с появлением термопластов с тщательно установленными физическими свойствами, близкими цветным металлам, техника машиностроительной конструкции теперь может эффективно использовать такие пластические материалы, с тем, чтобы добиться лучших рабочих качеств, сокращая при этом стоимость.

ЛИТЬЕ ПОД ДАВЛЕНИЕМ АЛЮМИНИЕВОЙ БРОНЗЫ

Ф. В. Фэрт Стр. 526

Автор раз'ясняет все стадии производства отливки под давлением алюминиевой бронзы на специализирующемся в этом виде производства литейном заводе. Он указывает также, какие можно выдельывать типы компонентов.

MATERIALS IN THE NEWS

Monthly Digest of Materials and Design News from Home and Abroad

Use of Computers in Engineering

MANY ENGINEERING PROBLEMS are complicated by large quantities of routine calculations, or by the necessity of taking many variables into account. Where such problems are relevant to the work of the National Engineering Laboratory, the electronic digital computer there is available to help industry.

An international committee including the United Kingdom is preparing new skeleton steam tables, based on all available experimental data and covering temperatures up to 800 deg. C. and pressures up to 1,000 atmospheres.

Although the international experimental determinations of properties have not yet been completed, N.E.L. have been investigating numerical methods for producing tables from existing data using the Deuce digital computer. In the past, most tables of thermodynamic properties have been derived from experimental data by graphical methods or by combined graphical and numerical methods. Such methods do not necessarily lead to consistent tables. High-speed computers, however, make possible the derivation of an empirical equation of state by purely numerical means. Having obtained the equation, the production of tables is a simple matter and, moreover, the tables of properties derived from the one mathematical expression are bound to be consistent.

Although the tables are of a preliminary nature, they have adequately demonstrated the possibility of using a digital computer in this type of problem. Copies of the tables are available on request.

In the design of many types of heat exchanger the designer has to carry out elaborate heat-transfer and pressure-drop calculations to arrive at the optimum design. Much of the labour and time involved in such calculations can be saved by the use of digital computers.

As part of an investigation into the heat transfer characteristics of feedheaters, N.E.L. have been developing a series of computer programmes for use in estimating the performance of feed-heaters and in interpreting the experimental results obtained from an experimental feedheater at present under construction at N.E.L.

One of these programmes has been completed, and while, at this stage, it is essentially in a form to meet the requirements of the N.E.L. project, it is believed that the programme may be of interest and use to industrial concerns. It estimates the surface area requirements of feedheaters of the type consisting of a desuperheating section and a condensing section, for given steamside conditions and feed outlet and flow rate conditions. In addition it provides, if required, the steam, feed and tube-wall temperature distributions within the feedheater.

Electro Humidity Transducer

AN ELECTRO HUMIDITY TRANSDUCER developed by the Phys-Chemical Research Corp., New York, U.S.A., is an electric hygrometric circuit element which senses changes in relative humidity by changes in ohmic resistance. The transducer is a processed plastics wafer, made from a chemically treated styrene copolymer, which has an electrically conducting surface layer that is integral with the non-conducting substrate. Changes in relative humidity cause the surface resistivity to vary. The absence of surface coatings or emulsions, and the high-temperature characteristics of the special styrene, result in a rugged sensor which is unaffected by condensation or water immersion. Since the humidity-sensitive portion of the sensor is restricted to the surface, a very rapid speed of response may be obtained to changes in relative humidity.

The sensor is unaffected by environmental conditions that are not detrimental to polystyrene—this includes most gases, and those liquids that are non-ionic. Dust settling on the sensor surface will not affect performance, except possibly to decrease slightly the speed of response. Electrical contact to the sensor surface is made by printed electrodes on both faces, convenient clip terminals being supplied for effecting circuit connections.

A single transducer is sufficient to cover the complete range of relative humidities from 0 to 100 per cent and it is slightly temperature-dependent. The temperature coefficient is accurately determined, and is linear over a wide range of temperatures and humidities. In applications where wide variations in temperature are not encountered, the temperature coefficient can be neglected.

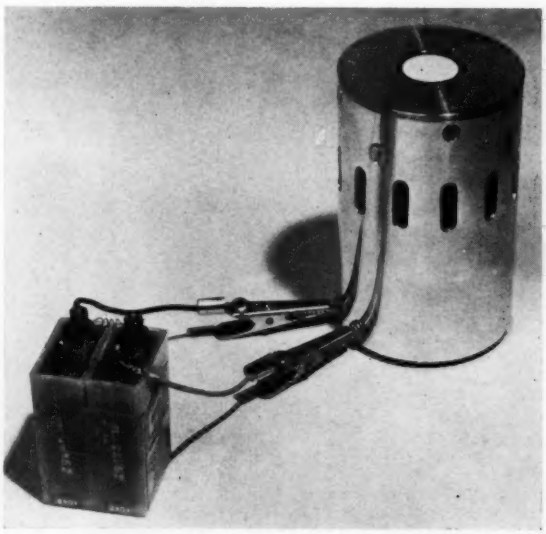
Thermoelectric Materials for Laboratory Use

A SMALL THERMOELECTRIC COOLER was recently demonstrated by de Havilland at Hatfield. It is intended for such applications as freeze cutting of sections in a freezing microtome, or it may be used as a carrier for specimens of animal or human tissue.

This cooler was only one of a number of exhibits of thermoelectric devices undergoing development by de Havilland who, as a result of investigation and research on the Peltier effect undertaken two years ago in connection with the air-to-air guided weapon programme, have been concentrating on applications of a commercial and scientific character. These include transistor coolers, and coolers for the precise temperature control of standard cells in instrument laboratories.

Although such applications are by no means new, de Havilland claim to be forging ahead with new methods of cutting the thermoelectric material at present being used, bismuth telluride, and to have developed some new methods of effecting the junctions. Some interesting ways of arranging multi-stage coolers of novel design were also demonstrated.

Thermoelectric cooler developed by De Havilland, showing the frost-covered insert.

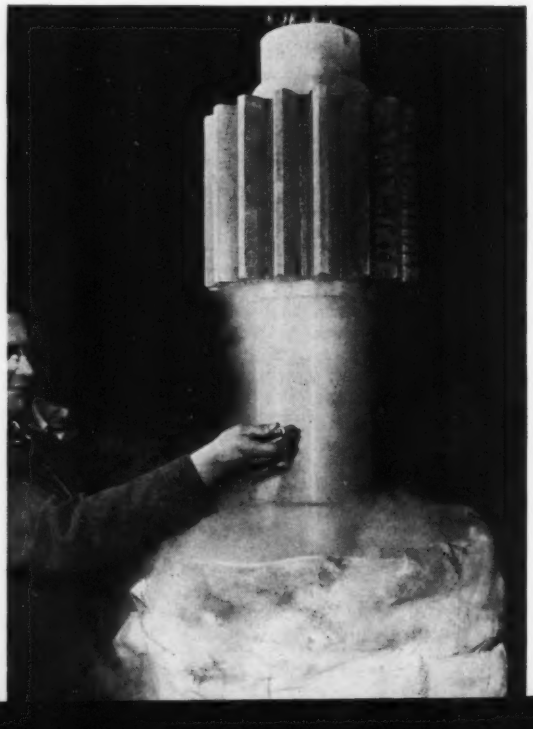


ELECTRIC RUNABOUT
This electric-powered vehicle, known as "Sparky," was one of six winners of the Alcoa Students Design Merit Awards for 1961. With a speed capacbility of 30 m.p.h. it has a sixty-mile range on one charge, and carries two persons in the forward cabin with an 800-lb. payload in the rear.

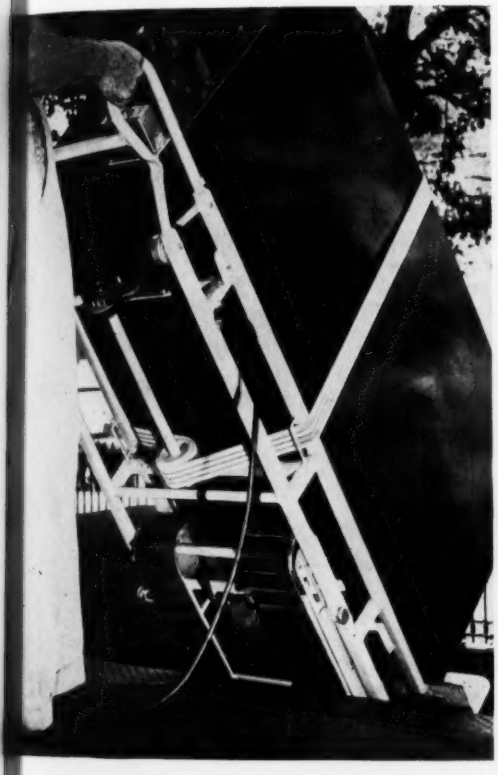
PICTURE NEWS
IN THE WORLD OF MATERIALS & DESIGN

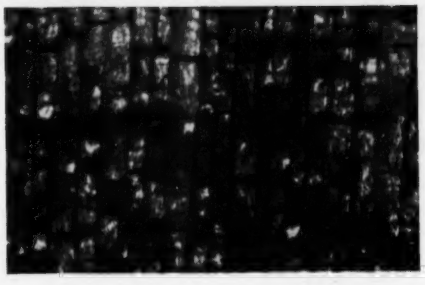
FOAM GIRDERS
Styrocell expanded polystyrene, made by the Shell Chemical Co., is finding increasing application for thermal insulation in the refrigeration and building industries. Weighing as little as 1 lb./cu. ft., it is made by a special process which expands beads of polystyrene up to sixty times their normal size.

NITROGEN FOR SHRINK ASSEMBLY
The use of liquid nitrogen supplied by British Oxygen Co. for assembling components on heavy machine tools can save time and money. Bayliss, Jones and Bayliss Ltd. plan to make increasing use of this technique—this picture shows a gear wheel pinion for a 300-ton billet shear being measured for contraction after being withdrawn from the liquid nitrogen.



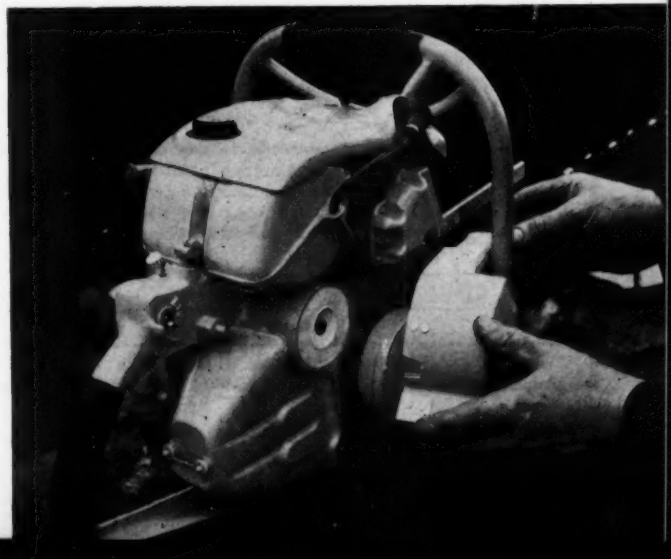
HYDRAULIC OPERATION OF LOCK GATES
Lockheed hydraulic equipment was recently installed by the Thames Conservancy at Shiplake Lock. Here the lock-keeper, standing at one of the remote control cabinets, has opened the sluice gates to raise the level of water in the lock; actuation of another lever will open the head gates in the foreground.





HEAT SHOCK PRODUCES SURFACE DAMAGE
Plasma bombardment of materials causes sudden heating of a thin layer of the surface, which breaks up into a mosaic of fine cracks; some spectacular effects were obtained recently by the U.K.A.E.A. The upper illustration shows soda glass (X 110), and the lower a single crystal of alumina (X 540), after a single discharge.

TRUCK CLIMBS STAIRS
By climbing up and down the steps on its two endless belts, the "Staircat" electrified hand-truck simplifies the movement of goods and equipment. It is manufactured by the New Design and Development Corp. of Lima, Peru, and uses cleated belts from the Goodyear Tyre & Rubber Co.



CORROSION-RESISTANT CLUTCH COVER
Reinforced plastics have replaced conventional materials for the clutch cover of the Danarm Direct Drive Chain Saw. The plastics cover gives improved protection and corrosion resistance, and at the same time enhances the saw's appearance.

CALL FOR PAYROLL TAX ON INDUSTRY
BIG PAYROLL TAX BILL FACES EMPLOYERS
The second new device will give the Chancellor power to impose a payroll tax on employers of 4s. a week for each worker. The 4s. would be added to the employers' National Insurance contribution and would go to the Exchequer.
(Ministerial cheers.)
PAYROLL PROPOSAL
4s. WEEKLY LEVY ON EMPLOYERS
Row flares over payroll tax

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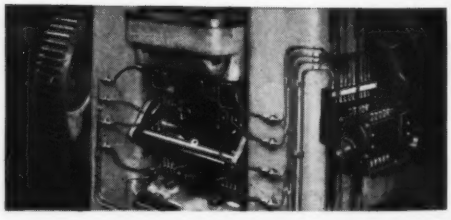

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Aluminium Coating of Steel Strip

AN ENTIRELY NEW PROCESS for producing aluminised steel strip has been developed at the Swansea Laboratories of the British Iron and Steel Research Association. The quality of the product is said to be superior to any other known aluminised strip, and the process is flexible, giving reliable coatings in the range 0.0001 to 0.001 in. thick on one or both sides. The coatings have an attractive appearance and are very uniform. Since no appreciable alloy is present, bends of 0.020 in. strip can be made over a $\frac{1}{16}$ in. mandrel without damage. The coating of aluminium is pore-free, and can be anodised and dyed, or vitreous-enamelled with a single-coat low-temperature frit.

The raw material for the coating is commercially available aluminium powder, and the process is carried out in three stages with a single pass. First, the powder is applied by passing the strip through a bath containing a liquid suspension of the powder. An electric current passing through the bath causes a migration of the powder towards the strip (electrophoresis) and the deposit thus formed adheres to the strip sufficiently for it to be dried and transported. The strip is then passed into a rolling mill for compaction—this is the second stage. A light pass only is necessary to give the coating adequate consolidation and a good appearance.

The third stage is heat-treatment, which is carried out in coil form by a new resistance-heating technique developed for this process. Excellent adhesion of coating is achieved by means of a specified time/temperature cycle without significant alloying occurring, and the coating itself is rendered ductile and strong.

Preliminary laboratory work has indicated that other metals and oxides can be deposited by the same method, and if required, on the same plant.

Industrial Applications for Graphite Fibres

THE DEVELOPMENT OF GRAPHITE FIBRES and textiles in the U.S.A., and their use for reinforcing plastics mouldings for high-temperature applications in rocket motors, has already been reported on in our July 1961 issue ("Progress with Refractory Fibres," by C. Z. Carroll-Porczynski, p.422). Graphite textiles are also finding increasing application in industry, notably as electrical heating elements because of their electrical conductivity and thermal radiation characteristics. They have been used as water immersion heaters (a 30 kW. graphite-fabric heater element can be stowed in a 1-litre container); as wall and ceiling panel heater elements for space heating; and for brazing (the Rohr Aircraft Corp. are brazing stainless steel honeycomb sandwich by means of localised graphite textile heaters). Graphite heater elements are also capable of brazing niobium at 1820 deg. C. in vacuum conditions.

Other applications for woven graphite textiles include high-temperature conveyor belts, in furnaces; impregnated with p.t.f.e., they are being developed by E.I. du Pont de Nemours as bearing bushes, because of their good self-lubricating and heat-conducting properties and their resistance to deformation. Such bearing bushes are expected to be less costly than bushes manufactured from solid p.t.f.e. loaded with graphite powder.

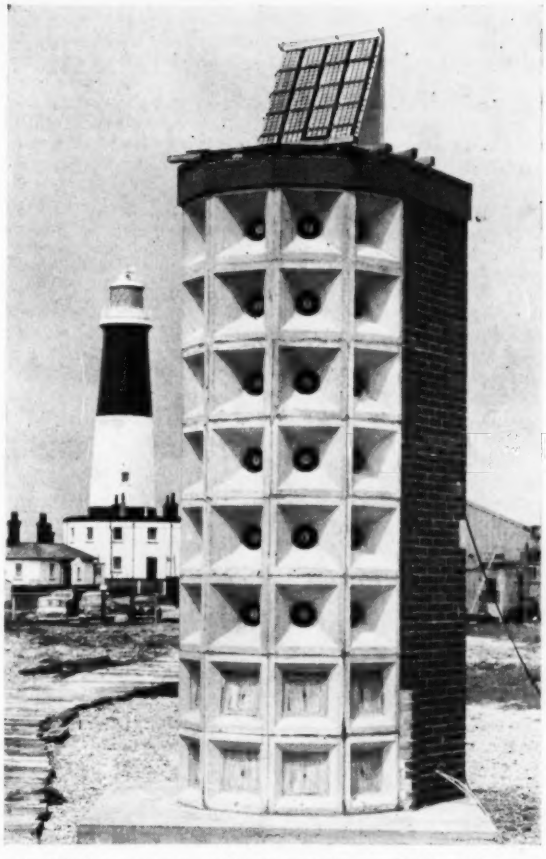
Non-woven graphite felts are being used for thermal insulation in furnaces, and graphite fibre yarns are being developed as packings for pump glands in the chemical industry, because of their unequalled corrosion resistance combined with self-lubricating properties, lower thermal expansion and good heat dissipation.

Solar Cell For Marine Buoy Lighting

MANY OF THE POTENTIAL APPLICATIONS for silicon solar cells, such as the sun-powered motor car or vacuum cleaner, are unlikely to be a practical proposition in the very near future. However, in the next few years it seems likely that these cells will be widely employed to provide power for re-charging batteries for marine buoy lighting.

At present, marine buoy lighting relies almost entirely on the use of stored gases, such as propane or acetylene. A change to the use of the solar cell would be advantageous, particularly from the maintenance viewpoint, because of its extreme reliability. The cell has a response time of a few microseconds, and can operate without deterioration under conditions of extreme temperature (—40 to +125 deg.C.) and humidity.

Experimental equipment which has already been built takes the form of a spherical glass bulkhead-type fitting in which a block of four Ferranti MS 11E silicon solar cells, wired in series, are mounted at an angle of inclination of latitude +15°. This ensures that a maximum charge is given to the 1.2 volt Nife storage cell throughout the year. In peak sunlight conditions the maximum daily charge is of the order of 250 mA.-hr. Each cell provides about 0.4 of a volt on load.



Installation containing 400 solar cells, at Trinity House experimental establishment, Dungeness, Kent.

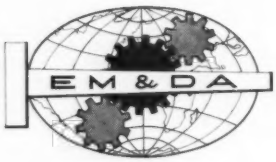
The next stage will be the construction of a model buoy, which will be tested in a static water tank to determine the physical configuration of solar cells mounted thereon when the buoy is subjected to the effects of wind and heavy seas. Buoy motion tends to reduce the power generated, as the solar cells are not always in the optimum position for maximum power output. In consequence, investigations should ultimately lead to the most suitable arrangement of solar cells, to ensure that even if some of the cells were shielded from the light because of the motion of the buoy, there would always be a surface generating sufficient power to charge the cell.

The Nife storage cell which will be mounted in the well of the completed buoy will be of the nickel-iron alkaline type, with a capacity of 45 amp.-hr. It will not only provide the power to operate either a low-wattage electric filament lamp or Xenon flash tube during the hours of darkness, but will also operate a transistor coder to give the light the desired character for identification purposes.

Rust-proof Aircraft Wheel

A NEW WHEEL, built by Goodyear in the U.S.A. to meet the severe operating requirements of high-speed jet aircraft, is constructed mainly from titanium and has successfully passed all necessary tests. Among many interesting features is its ability to withstand more than 540 deg. C. It is also corrosion resistant, this being an inherent property of titanium.

The titanium wheel is very light and due to its high strength/weight ratio it leaves more space for brakes because its sections are thinner. It can also withstand greater impact loads without failure because of its superior flexibility. Since titanium conducts heat at a very low rate, little brake heat is conducted to the tyres.



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This should interest you!

FOLLOWING THE INTEREST aroused by *Engineering Materials and Design* (which led to the sponsorship of the first Engineering Materials and Design Conference and Exhibition, at Earls Court), and as a logical development to meet the obvious need for a designers' forum, an Engineering Materials and Design Association is planned. This will be open to engineers, designers and technicians, and others who have an interest in or are associated with engineering.

AIMS & OBJECTS

1. *To promote, encourage and improve design in all branches of engineering and allied technologies.*

2. *To foster and facilitate the interchange of information, ideas and practices by holding conferences, visits and social meetings. Visits will include factories, research organisations and international events.*

3. *To stimulate discussions and the practical interpretation of theoretical and other aspects of design.*

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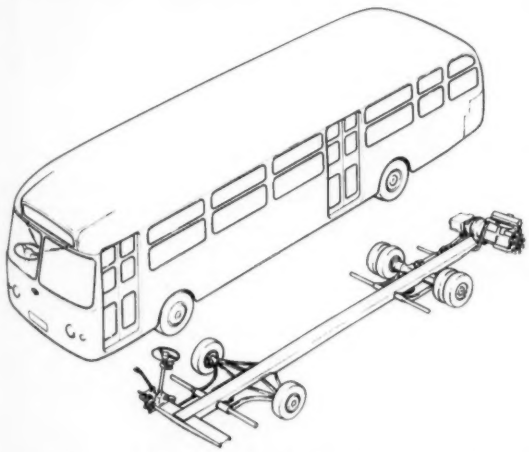
The Bus of the Future ?

SEVERAL PROVOCATIVE DESIGN IDEAS for an ultra-lightweight city transit bus of the future were recently put forward by the chief engineer (vehicles) of Leyland Motors Ltd. With the increased use of motor cars, it is becoming virtually impossible to provide a satisfactory solution to parking and traffic requirements, especially in the older-established cities, and therefore the public will eventually turn more and more to the use of the single deck transit bus for short-haul transportation into the "down-town" centres of larger cities.

The provision of new and attractive vehicles necessitates some re-thinking on the part of the bus engineer, especially if new passengers are to be attracted away from motor cars—fast loading and unloading of the vehicles is a desirable concept. Furthermore, there is a growing demand throughout the world for a reduction in operational costs, as well as a reduction in the purchase cost of new vehicles.



The ideal new bus would be 36 ft. long and 8 ft. 2½ in. wide. Its weight, ready for the road, would be as low as 3¼ tons. There would be seats for forty-eight and its maximum load including standing passengers would be seventy-five persons. A 125 h.p. diesel engine, similar to the Leyland Power Plus 400-S, would be installed transversely at the rear, together with a four-speed fully automatic gearbox with torque converter input combined with a direct drive lock-up automatic clutch. The gearbox, which has already been developed, would have its output shaft mounted transversely amidships to allow the transmission line to be longitudinal.

Another feature would be the chassis, consisting of a single longitudinal member of "spinal cord" construction, tailored to receive an integral body assembly. This backbone would carry all the suspension loads, while the engine gearbox pack would be installed on a transverse structural member at the rear. Steering and controls would be fitted to a forward transverse member. All brakes would be discs, hydraulically operated with air boost, and suspension would be full air for front and rear. The maximum height of the floor would be only 18 in., and the rear axle would consist of a rigid beam with integral arm location.

Durability and light weight would be the main features of the body, which would be built from one-piece mouldings in natural finish glass fibre reinforced plastics. Construction would be by a series of inner and outer section mouldings finally "glued" together with epoxy resin adhesives and reinforced by uni-cellular or honeycomb fillers. Even the seats would have plastics frames. Entrance and exit would be by one step only, and moulded heating ducts would be built into the body.

Tests have shown that such a bus can achieve over 13 m.p.g. fully laden at five stops per mile on a level road. At a continuous 30 m.p.h., it returns more than 23 m.p.g.

Transformer resists Temperature of 650 deg. C.

THE HIGH TEMPERATURES within the nose cone of a missile re-entering the earth's atmosphere will melt most standard electric equipment. A new transformer being built by Raytheon Company, of Massachusetts, under a special contract for the U.S. Navy Bureau of Ships, can resist temperatures—some 450 deg. higher than transformers now in use. The Microwave and Power Tube Division of the company is now constructing the high-temperature resistant units for final testing; the development programme has been aimed at demonstrating the possibility of building a transformer which can withstand red-heat conditions.

The temperature limit of transformers presently in use is about 200 deg. C. Under the first stage of the contract, Raytheon engineers developed a transformer which could withstand up to 370 deg. C. The goal of prototypes now under construction is a minimum operation time of 2,000 hr. with the units' internal temperature 110 deg. above an ambient temperature of 540 deg. C. The prototypes will represent the various types of transformers.

Although the new transformers will be utilising a glass fabric covered wire and mica layer insulation, new high-temperature resistant insulating materials have now been developed. A bentonite clay compound which can resist temperatures up to 540 deg C.. can be made in sheets as thin as 0.005 in., and may be strengthened with inorganic fibres such as glass, quartz or asbestos, depending upon the heat resistance needed. Another development is a copper-tantalum wire. Upon being anodised, this wire receives a tantalum oxide insulated coating which resists high temperatures.

Nickel-coated wiring now on the market has limited heat resistance, because it will alloy with copper at high temperatures, so the firm's engineers have also developed a chromium-plated copper wire to which is fused a ceramic formulation. This chromium-plated wiring will not alloy with copper at high temperatures, and has 50 per cent more conductivity than nickel-plated wire.

Advance of Glass-reinforced Resins

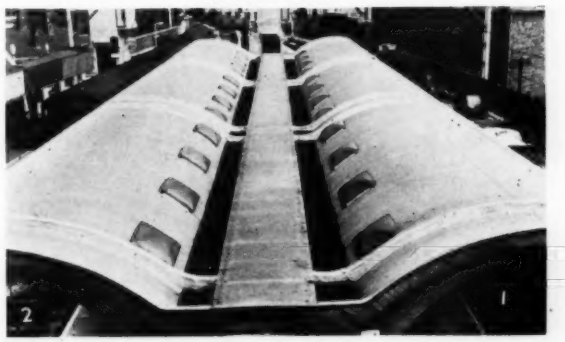
ONE OF THE MOST OBVIOUS FEATURES at the International Plastics Exhibition 1961 was the considerable advance in the use of glass-reinforced polyester resins—examples of moulded boat hulls, car bodies and storage tanks could be seen on all sides.

The most interesting feature in the development of these materials was not just the number of resins available or the variety of products, but the styling. The most obvious example of this was the glass-fibre railway signal relay station described by British Railways as a "revolutionary new building". It has a very futuristic appearance with a "bulbous" shape, giving the appearance of a prefabricated igloo. Apart from the design, there were a number of practical considerations which prompted the use of the materials involved. For example, the building was erected in only a few hours, a most important point in inaccessible positions. In addition, the shining white plastics, self coloured and weatherproof, required next to no maintenance or decoration. The building was manufactured from Deeglas by Mickleover Transport Ltd., using Beck, Koller & Co. (England) Ltd. resins, and a full scale replica was featured at the exhibition.

The number of attractive looking boat-hulls was outstanding. Some of these were beautifully styled with the usual dazzling white finish. There were also a number of sports car bodies with their well-known complex curves, for which the glass reinforced products are ideally suitable.

Fothergill and Harvey Ltd. have been giving much attention to the design of suitable glass fabrics for these products. Normally, articles of complex shape are made by applying a number of comparatively small pieces of fabric around the complex curves. This is far from satisfactory, and Fothergill and Harvey are now weaving fabrics in three dimensions to give a first-class answer to the problem.

Translucent roof domes (at Oxford Road Station, Manchester) moulded by Galt Glass Laminates Ltd., using Scott Bader polyester resins.



Flame-spraying Steel on Light Metals

MANUFACTURERS OF LIGHTWEIGHT PETROL ENGINES used in portable power equipment for home and industrial use operate in a highly competitive field where the constant trend is toward lighter weight, greater power, more reliability and longer life. Some of these engines develop over 5 h.p. and weigh less than 14 lb., thus a saving of a few ounces is important. They are also subjected to considerable

abuse, operate at high temperatures, and are rated well over 3,000 r.p.m. In order to produce these lightweight engines, diecast aluminium alloy cylinders are used in which an iron liner is normally pressed to provide a hard bearing surface for the aluminium piston. This liner weighs as much as ¼ lb.

In work conducted to date, the Metallizing Engineering Co. in the U.S.A. are replacing the liner by a thin coating of molybdenum and steel sprayed directly on the cylinder walls by two Type K Metco Metallizing Machines, which are controlled by push-button electric panels. The initial bonding coat is Sprabond Wire, followed by Sprasteel L.S. This latter is a low shrink material, the final result, after hone finishing, being a hard steel surface only 0.007 in. thick. The total coating weight can be measured in gm., and replaces the ¼ lb. sleeve. Furthermore, the inherent porosity of sprayed metal gives excellent oil entrapment qualities which aid materially in the lubrication of the piston. In the U.K., similar work is being carried out by Metco Ltd.

THE SEPTEMBER ISSUE

of *Engineering Materials and Design* will include the following main features:

Polypropylene—The Insulator of the Future
Brief account of the nature, engineering properties, and basic methods of fabrication of this material.

Design of Visual Indicators: Part I
Setting out the design principles to be observed, and giving examples of good and bad design.

Know Your Metals—Iron
A simple treatment of the subject of iron and steel, for the junior designer who has not been trained in metallurgy.

Survey of Pipe Couplings: Part 2
Listing the principal manufacturers of the following types of pipe coupling: screwed, welded, brazed, soldered, capillary, flanged, self-sealing and quick-release.

Disc Brakes for Railway Waggons

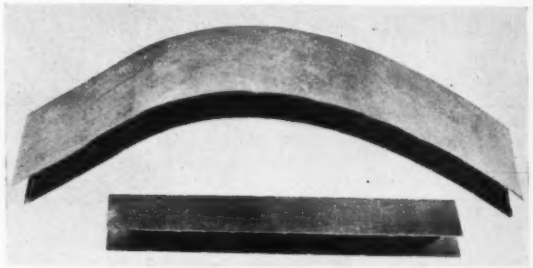
BRITISH RAILWAYS are placing into regular service express freight waggons using disc brakes; this is the first railway system in the world to do so. In this design the wheel itself is being used as the disc. The adaption of disc braking has been developed by the British Transport Commission in conjunction with Girling Ltd. Large scale trials are to be carried out on 212 coal waggons of three types under service conditions.

The first batch of vehicles equipped with disc brakes is sixty-two 21-ton hopper-type coal waggons which discharge their load through the bottom of the vehicle, and which regularly form three express freight trains a week on the Eastern Region's Great Northern Line. Another fifty 16-ton mineral type, and 100 24½-ton hopper-type waggons, are also to be fitted with disc brakes.

The automatic two-stage disc brake consists essentially of a double fulcrum device mounted with a horizontal diaphgram-type vacuum cylinder, one of the two fulcrum points being selected automatically according to whether the vehicle is loaded or empty. The force from the vacuum cylinder is transmitted via the leverage selected to a caliper mechanism which forces non-metallic brake pads against machined faces on the webs of the rail wheels.

Roll-welding Corrugated Core Sandwich Panels

CORRUGATED-CORE SANDWICH PANELS of aluminium alloy, titanium, steel, molybdenum and Inconel have been successfully produced at substantially reduced costs in a new process known as roll-welding, developed for the Douglas Aircraft Company by research metallurgists of the Battelle Memorial Institute. The method requires no jigging, provides completely sound core-to-cover bonds, and allows the panels to be extensively formed after assembly. The peaks of the corrugated metal core are pressure-welded to the face sheets by a hot-rolling process. The size of the sandwich panels is limited only by rolling-mill capacity. Panels ¼ in. thick measuring 36 × 72 in. have already been produced.



To form the corrugated core, an accordion-pleated sheet of metal is woven over and under V-shaped inserts of a chemically-soluble deformation-resistant metal such as copper or iron. A rectangular metal frame is placed around the core, and the face sheets of the sandwich are added. The entire assembly is clamped in place by two additional metal cover sheets, which are welded to the rectangular frame. The whole package is then hot-rolled in a direction parallel to the corrugations. The rolling process also reduces the thickness of the panel up to 60 per cent to provide desired corrugation shapes.

After rolling, the retaining frame is sawed or sheared off, and the metal covers welded to the frame are peeled away. With the support wedges still in place, the sandwich panel can now be formed into a variety of shapes, including hemispheres, without buckling the core. Standard tooling can be used, and the panel can be worked as though it were a solid metal plate of equal thickness.

The V-shaped inserts are then leached out of the formed structure with a chemical reagent such as nitric acid. Although the leaching process requires several days for very large panels, it is a straightforward operation and is relatively inexpensive. If necessary, leaching can be accelerated by mechanical means.

Since core design is determined by the design of the filler wedges, roll-welding can also be used to produce sandwiches with vertically ribbed cores. The only limitation is that the core must be unidirectional.

Roll-welded corrugated sandwich cores are claimed to approach the all-round rigidity of honeycomb sandwiches, and to be simpler and much less costly to manufacture.

NEW EDITOR FOR E.M.&D.

R. D. CULLUM

FOLLOWING the appointment of H. R. Heap, B.Sc., A.M.I.E.E., as managing editor, the editorship of *Engineering Materials & Design* will from this issue be in the hands of R. D. Cullum, M.I.E.D., A.R.Ae.S., M.I.A.S., who was formerly technical editor. This move has become necessary with the advent of the new weekly newspaper *Engineering News*, the first issue of which appears on October 5.

Mr. Cullum has been technical editor of *E. M. & D.* since its inception, and has worked closely with Mr. Heap to provide the service which readers have come to expect. No change in policy will be made, and *E. M. & D.* will continue to publish information and data which is both useful and of topical interest to designers and engineers in various industries.

Mr. Heap will be able to use the knowledge and experience gained while he was editor of *E. M. & D.* to good advantage in guiding the specialist staff of *Engineering News*, which will provide a comprehensive and authoritative coverage of engineering developments on a broad front. He will also integrate the policies of both *E. M. & D.* and *Engineering News* to ensure that the readers obtain the maximum benefit from both publications.

H. R. HEAP

THE HUMAN ELEMENT IN INDUSTRY

AN UNTAPPED SOURCE

THE importance of properly training Britain's skilled men was emphasised to industry and public alike by the national events held during the Duke of Edinburgh's Commonwealth Technical Training Week. E.I.G.A. (Engineering Industries Group Apprenticeship) is a scheme, run by Industrial Administration (R. & A. Ltd.), specially designed to assist small companies in the training of apprentices, and has evoked considerable interest from industrialists. Up to now, many small companies have not been able to accept apprentices because as individual firms they have lacked facilities, but by grouping together and exchanging apprentices for various periods they will be able to provide training comparable to that of large companies.

Such a scheme has a number of other advantages. For example, when an apprentice finishes his time he feels a natural desire to move on and test his skill against new challenges in other companies. This means that to a large extent industry is dependent upon large companies for a constant supply of craftsmen and technicians. But with the group scheme a youngster may work out his wanderlust while serving his time. Moreover, in moving from firm to firm a boy gets a social education as well as a technical one. At each new company he meets new workmates and new managements, and also has the opportunity to study varying conditions in the different firms.

With solid support from small companies, such a scheme as E.I.G.A. could well double the number of skilled men in ten years. The time to put it in operation is now, while the problems of a "bulge" in the number of school leavers are being faced.

E.I.G.A. now has twenty-two groups in the Home Counties, Midlands, North West, and Gloucestershire and in each group there are from fifteen to twenty-five firms and up to sixty boys. Altogether, the scheme looks after the training interests of some 380 firms providing 1,000 places. Detailed syllabuses for over forty different trades ensure that each boy is given the right training, attends the right courses, and takes the right exams. These numbers include six firms, each having one apprentice, who have formed the nucleus of the first Commercial and Administrative Apprenticeship Group, which has recently started operating in the Midland Region.

Examination results for E.I.G.A. apprentices in the 1960 City and Guilds show 69 per cent successes, which is considerably above the national average, and provides a further indication of the success of the selection and training methods.

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NOISE – THE CHILD OF PROGRESS

THE total acoustic power radiated into the air by a modern jet aircraft used for commercial flights is tremendous —more than 100 kW. This fact was disclosed by Fritz Ingerslev of the Royal Technical University, Copenhagen, during the recent conference on The Control of Noise, held at the National Physical Laboratory under the sponsorship of D.S.I.R.

Noise is usually a useless by-product of a mechanical device, but its nuisance value is often out of all proportion to the actual power being radiated as noise, so that there is seldom an incentive to the designer to lower the noise level of his products on the grounds of improved efficiency. Therefore, if anything is to be done about reducing the noise level in our cities and our factories, it will have to be by some form of legislation. In fact a start has already been made in the Noise Abatement Act which recently passed into law. Noise is not an easy subject to investigate because of the many subjective factors involved, but the Government is taking this problem very seriously, as was indicated when the Minister for Science set up a committee just over a year ago, under the chairmanship of Sir Alan Wilson, to study the problem of noise and advise what measures could be taken to mitigate it.

The task of bringing in legislation is not an easy one, because one man's noise can be another man's thrill. The roar of a Grand Prix racing car engine, or the discordant clanging of a "pop" record, can induce anger or ecstacy according to the taste or even the mood of the listener. However, these are problems which need not concern the engineer at the moment, and in any case there is reason to hope that the mere threat of prosecution may to a large extent be sufficient to prick the conscience of those responsible for making noises.

The engineer has a part—a very important part—to play in helping to reduce the noise level of machinery, whether it be for use in factories, in public highways or at home. We are well aware that an engineer's attitude to noise is too often apathetic; in fact some designers have shown a tinge of pride when demonstrating a new engine or production machine which generates a cacophony, making conversation almost impossible. In such cases noise becomes a kind of symbol of success, but it is really an incidental factor because very few engineering designers take noise into consideration in the design stage. If a machine proves to be too noisy for the customer, attempts may be made to enclose it, but all too infrequently is a serious effort made to reduce the noise at source. In some cases the remedy is simple, as with some noisy gear trains, where the use of fibre or reinforced plastics for intermediate gears may have a significant effect, but in other cases the remedy may be uneconomic. It is probably true to say that the technical cure for most mechanical noises is known, but it is not always practicable to apply the appropriate silencing technique.

While scientists are investigating the nature of noise and the means for measuring it, and while the politicians are looking into noise abatement laws, the engineer should be examining his designs with two objects—firstly, he can make better use of existing knowledge by incorporating such things as resilient mountings, or silencers on pneumatic equipment; and secondly, he should investigate a fundamentally new approach to inherently noisy machines. Could he not devise a rotary drill to replace the pneumatic drill, or invent a quieter drop-stamp forge? Impact devices do not have to be noisy, as we have seen with the Cox gun, which will fire a ¾ in. stud through steel plate with little more noise than a loud click.

The Editor

MoS_2 ENHANCES WEAR RESISTANCE OF NYLON

This article consists mainly of a description of how controlled amounts of molybdenum disulphide, homogeneously dispersed in nylon, allow parts to be produced having superior wear resistance at competitive cost

by P. D. MITCHELL*

DESIGN engineers and injection moulding companies are currently becoming aware of the fact that controlled amounts of molybdenum disulphide homogeneously dispersed in nylon are allowing parts to be produced having superior wear resistance at competitive cost.

Injection moulded parts exhibit lower coefficients of friction and wear rates combined with better dimensional stability and abrasion resistance when compared with ordinary nylon. Moulders have reported that time and hence costs can be reduced by the use of faster moulding cycles with reduced mould lubrication and easier ejection of the part, which itself shows less shrinkage and distortion.

These facts combine to show that the addition of precise quantities of molybdenum disulphide to nylon improves a wide range of characteristics, and gives a superior performance to the part concerned, hence extending the range of applications of industrial plastics. This improvement is not unexpected in so far as molybdenum disulphide (MoS_2) has been shown by many tests to be one of the best solid lubricants currently available. For example, according to figures compiled during press-fit tests, natural MoS_2 has a kinetic coefficient of friction that is only one-third of that shown by the next best lubricant.

Design engineers are naturally interested in the end results of the addition of molybdenum disulphide to nylon. One of the best ways to illustrate these results is by comparison with conventional Type 66 nylon, the latter being the grade most used at present for mechanical and wear resistant general purpose applications.

The physical properties of Nylatron G.S., the combination of MoS_2 and nylon produced by Polypenco Ltd., are shown in Table 1, while comparative wear rates are illustrated in Fig. 1. These improved major properties, apparent from the Tables, can produce outstanding results when translated into terms of actual component design.

Wear Resistance

Molybdenum disulphide filled Nylon 66 bearings, wear strips and gears have shown a life increase of 100 per cent in many cases compared to equivalent ordinary nylon parts. This fact can be predicted by study of the test data shown in Fig. 1, which shows that the wear rate for Nylatron G.S. is approximately half that of Nylon 66. A 300 per cent increase in length of service was obtained by using Nylatron G.S. bearing shoes in an escalator application replacing standard nylon parts previously used, while Nylatron G.S. household food mixer driving gears showed an increase in wear resistance of between 70 and 100 per cent.

The abrasion resistant properties of Nylon 66 are well known, and have led to the widespread use of this material for many wear-resisting applications. Nylatron G.S., by comparison with Nylon 66, exhibits superior abrasion and wear resistance. As a dry bearing, for example, Nylatron G.S. may be used at p.v. (pressure-velocity) ratings up to 50 per cent higher than Nylon 66. MoS_2 added to Nylon 66 enables a bearing to run cooler, quieter and more smoothly with less generated friction, thus reducing heat build-up. The material is harder and stiffer than ordinary nylon, and established fits and running clearances can be maintained over a wider temperature range.

Component parts manufactured from Nylatron G.S. can often be used as replacements for orthodox metallic components where problems of high rates of wear are encountered. For example, metal actuating levers, cams and bearings used in a 500 V., 150 amp. switch needed replacement after only 500,000 to 600,000 operating cycles. The substitution of Nylatron G.S. has enabled test switches to be cycled more than 18,000,000 times without failure.

Dimensional Stability

Extremely close tolerances and a high degree of dimensional stability are often called for in many wear resistant applications in the fields of mechanical and electrical engineering. Such a component is the slide shown in Fig. 2, for "pushing" and positioning cards for a collator on a piece of data processing equipment.

Type 66 nylon, machined and subsequently assembled, was used to fabricate this component during the early development stages, but the 5-in. long guide tracks required lubrication to ensure smooth movement. The lubricant itself caused dust accumulation, and hence poor operation of the slides

*Technical sales manager, Polypenco Ltd.

Table I. Physical properties of Nylatron G.S.

Property	Units	A.S.T.M. Method	Nylatron G.S.	Nylon 66
Tensile strength at 23°C.	p.s.i.	D.638–52T	12,300	11,800
Modulus of elasticity at 23°C.	p.s.i.	D.638–52T	575,000	400,000
Flexural strength at 23°C.	p.s.i.	D.790–49T	18,000	13,800
Impact strength, Izod at 23°C.	ft. lb./in.	D.256–54T	0.62	0.94
Heat distortion temperature at 264 p.s.i.	°C.	D.648–45T	163	94
Coefficient of linear thermal expansion ..	in./in./°C.	D.696–44T	6×10^{-5}	10×10^{-5}
Dielectric strength (short time)	V./mil.	D.149–55T	356	385
Specific gravity		D.797–48T	1.16	1.14
Water absorption	%	(Note 1)	0.80 (24 hr.) 1.14 (48 hr.)	1.10 (24 hr.) 1.48 (48 hr.)
Flammability	in./min.	D.635–44	self extinguishing	self extinguishing
Colour			grey to black metallic	buff to white
Deformation under load	%	D.621–51	0.8	1.0
Brittleness temperature	°C.	D.746–55T	–15	–30
Kinetic coefficient of friction against steel ..			0.16–0.2	0.2–0.3
Melting Point	°C.		264	264

Note 1:—*Test according to A.S.T.M. D.570-42, except the specimens were $\frac{1}{2}$ in. dia. × $\frac{1}{8}$ in. thick.*

Note 2:—*The data above for Nylatron G.S. was obtained using annealed test specimens. The property values are intended for engineering purposes, and as they are average values they should not be used for specification purposes.*

rapidly became apparent. By using Nylatron G.S., surface lubrication of the slides was dispensed with completely. Dimensional stability was of course essential, and the part showed no distortion despite the $\frac{1}{8}$ to $\frac{9}{16}$-in. range of wall thicknesses.

Shrinkage and distortion are linked very closely to internal stress, hence it becomes necessary to consider their combined influence. Nylon plus MoS_2 shows lessened and more uniform shrinkage than conventional nylon for any given section. From Table 1 it may be seen that the coefficient of linear thermal expansion is approximately 40 per cent lower than that of Nylon 66, thus offering improved size control in addition to more accurate moulding tolerances.

A marked reduction in internal stresses is found in addition to the reduced shrinkage in any given item. All injection-moulded parts have of course some residual stress after moulding, but the high degree of crystallinity associated with Nylatron G.S. considerably reduces this built-in stress.

The primary source of internal stress in any injection-moulded nylon part is caused by the different characteristics of the outer amorphous layer of the part and the more crystalline central mass. The lack of uniformity in the structure of these layers in addition to a predominance of the amorphous layer, or the latter property alone, will impart a high degree of stress to the moulding, resulting in non-uniform shrinkage or distortion.

In massive sections most of the volume of the material is crystalline in nature, hence the physical characteristics of this crystalline structure predominate. As moulded sections become thinner the outer layers of amorphous structure constitute a greater percentage of total thickness, and the dimensional changes or distortion produced by internal stresses subsequent to moulding become more pronounced.

The disc shown in Fig. 3 provides an excellent example of the reductions in distortion and uniform shrinkage which are possible. As indicated dimensionally, the design of the disc incorporates a slight curvature, and measurements were

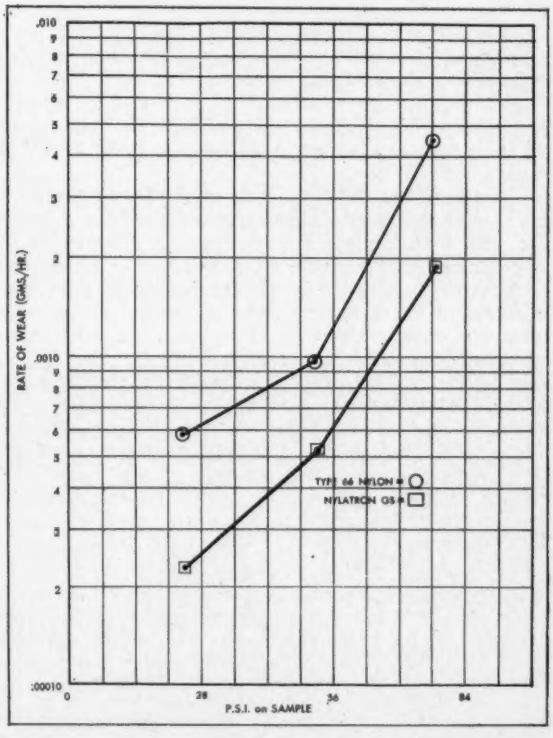


Fig. 1. Accelerated wear tests were made to indicate the relative rates of wear between MoS_2-filled and unfilled nylon. Both specimens were run against steel previously cleaned with carbon tetrachloride. The surfaces were not lubricated, and the rubbing velocity of 1,165 r.p.m. gave a surface speed of 160 linear ft./min.

recorded from the peak of this curvature to a flat surface on which the parts were placed.

The figure obtained from an injection-moulded part in ordinary nylon was 0·557 in.—this figure was reduced to 0·217 in. for Nylatron G.S. parts. In other words, the ordinary nylon distorted more than six times as much from the nominal dimension of $\frac{1}{16}$ in.

The other major factor affecting dimensional stability is that of moisture absorption. All nylons are hygroscopic, and in common with these Nylatron G.S. will absorb moisture until equilibrium conditions are reached, resulting in a dimensional increase in the part size. However, the new composition shows a 25 per cent reduction in moisture absorption when compared with Nylon 66, and this property is of particular importance when used for the manufacture of parts such as the submerged pump impeller shown in Fig. 4.

These impellers, moulded in the molybdenum disulphide resin, are more efficient, less expensive and have a longer life than impellers made from brass or ordinary nylon. Impeller efficiency is greater owing to improved smoothness of the water passages. The part in question is fully submerged in operation, but there is no distortion problem owing to the lower hygroscopic expansion of Nylatron G.S. when compared to Nylon 66.

Heat Distortion

Another company made use of the resistance to heat distortion of molybdenum disulphide filled nylon by re-designing an oven door assembly to obtain a cost saving of between 10 and 20 per cent. Tests conducted with Nylatron G.S. showed that it possessed greater heat resistance than other nylons to the extent of distortion resistance at temperatures up to 162 deg C. under a point-contact 13-lb. load. Further tests indicated that the parts had double the wear resistance of ordinary nylon mouldings in this application. The MoS_2 filled nylon composition manufactured by Polypenco Ltd. can be seen from Table 1 to exhibit 20 per cent lower deformation under load than standard nylon.

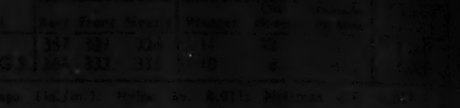
Additional Design Advantages

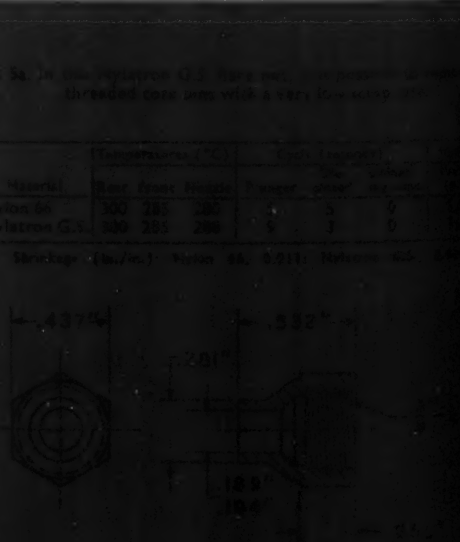
Nylatron G.S. is unaffected by alkalis and most solvents, including the hydrocarbon range of chemicals. The material has excellent electrical insulating properties, exhibiting a low dielectric constant with a relatively high dielectric strength. In addition, the physical properties of a part moulded from Nylatron G.S. are almost equivalent to those of prototype parts machined from solid extruded material, thus showing another distinct advantage over ordinary nylon, where the properties can vary considerably from the machined prototype to the moulded production article. This is, of course, a distinct advantage from the viewpoint of design of both the component part and the mould.

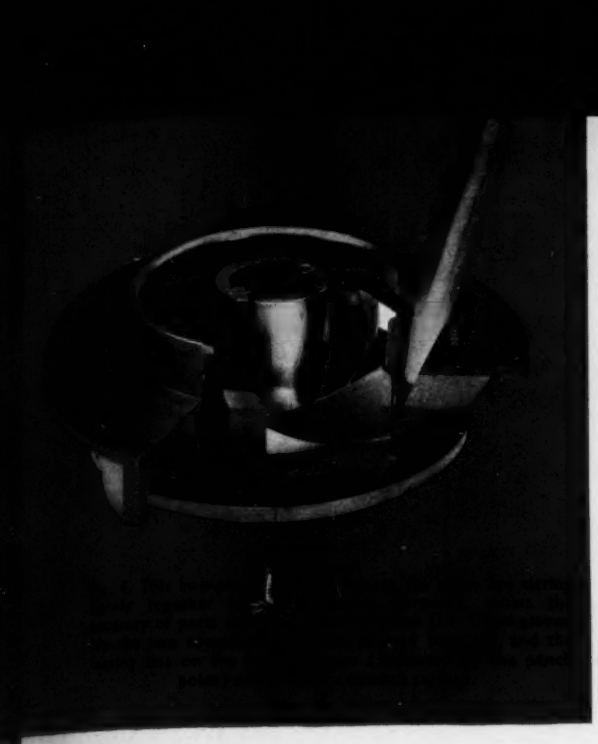
Moulding Advantages

Most of the advantageous costs found when using the molybdenum disulphide filled nylon are derived from improved moulding properties that permit economies in the production of wear-resistant components. Such economies are of prime concern to the design engineer, and in general the improved properties of Nylatron G.S. are available to him at no greater, and frequently less cost than that of standard nylon items.

While readily moulded on standard injection moulding equipment, moulding cycles using Nylatron G.S. are often faster. For example, for the parts shown in Figs. 5a and b, moulding cycles using Nylatron G.S. are from 20 to 33 per cent faster than those obtained when using Nylon 66. The die closure time is lower for both items, while the plunger







cycle is lessened in the case of the bearing block.

Less scrap is often obtained. Here the inherent lubricating qualities of MoS_2 render it possible to remove the threaded core pins from the flare nuts with very low scrap rates. Ordinary nylon caused time-consuming interruptions of the cycle of operations by seizing on to the core pins.

Mould lubrication can be reduced and often eliminated entirely by using Nylatron G.S. The bearing block shown in Fig. 5b, when moulded in ordinary nylon, showed a tendency to stick in the stationary half of the mould, caused by flashing of material at points where the core pins were made to "kiss off" or butt together to form a seal. Owing to this sticking it was necessary to lubricate the mould after every few shots. By the use of Nylatron G.S., however, very little lubrication is now required, as the flashing has been completely eliminated.

Crystallinity

The obvious advantages of greater wear resistance and lower coefficient of friction are the contribution of the inherent lubricating qualities of molybdenum disulphide to the nylon. This does not explain the other enhanced properties of the material, characterized by higher heat distortion temperature, increased flexural strength and modulus of elasticity, and improved dimensional stability. The superiority of these properties is the direct result of the greater crystallinity of the material.

With ordinary nylon, injection moulded parts have relatively low non-uniform crystallinity. The rapid cooling and quenching undergone by the molten nylon as it contacts the surface of the mould produces an almost completely amorphous or non-crystalline skin; it is therefore frequently necessary to lubricate standard nylon moulded parts, as this layer does not possess optimum bearing qualities.

There is a considerable difference in structure between the outer layer and the inner mass of a conventional nylon part, hence a high degree of stress is moulded into the part, with consequent loss of rigidity.

To demonstrate the improvement in the properties of Nylatron G.S. over standard nylon mouldings, the extremely thin section disc shown in Fig. 3 was moulded in both this material and in Nylon 66, using the same equipment. The representative samples used in the test comparison were taken from the parts moulded with the fastest cycle time in each type of resin. Several size comparisons were made and photomicrographs taken (see Fig. 6) showing the crystalline structure of the parts more than eight months after injection moulding the discs.

From Fig. 6 (*2762*) it may be seen that the lighter area, making up the right hand third of the piece, is almost entirely amorphous. The middle third shows striations of crystallinity appearing as darker streaks and making up one third to one half of its area, whilst the left hand third at the base of the sample is essentially all crystalline except for the amorphous edges.

By comparison with the Nylatron G.S. part shown at *2761*, it may be seen that the latter exhibits full crystallinity even to the tip of the disc. The solid grey colour of the piece is caused by its very fine, even crystalline structure. The amorphous skin shown on the Nylatron G.S. part is very thin, but, of even greater importance, it is uniform, and since the part is mostly crystalline in structure, less over-all shrinkage can occur. Although it was impossible to obtain a strictly quantitative comparison of the thickness of the amorphous skin on the parts in question, the Nylatron G.S. part had a uniform skin of slightly less than 0·001 in. thickness, while that of the Nylon 66 part varied from 0·003 in. to 0·004 in. Nylon 66, therefore, had a 75 per cent greater content of amorphous material with over four times the non-uniformity or variability in structure of Nylatron G.S. It is important to realise that, by keeping the amorphous layer thickness to

a minimum, the bearing qualities of the MoS_2 additive are more fully utilised.

Comparison of Dimensional Control

A size comparison of these discs after ageing at room temperature for over eight months showed that the Nylon 66 item was much thicker, especially at the tip.

The Nylatron G.S. part grew far less after moulding, thus resulting in a thinner and more uniform piece. To compare the growth after ageing, careful measurements of the thickness of the discs at sixteen equally spaced points around the tapered edge were made on a 0·001 to 0·002 in. ridge incorporated in the mould design $\frac{1}{32}$ in. in from the edge. The average micrometer readings at the above-mentioned stations were 0·030 in. for the Nylatron G.S. part with a maximum reading variation of 0·008 in. while the Nylon 66 results were 0·039 in. average with a maximum variation of 0·014 in. Conventional nylon therefore exhibited a 30 per cent increase in hygroscopic expansion and a 75 per cent increase in dimensional variation when compared with Nylatron G.S. It will be noted that the rate of moisture absorption of nylon is a function of crystallinity and, in fact, crystallinity promotes nearly all the desirable properties of the material, including the degree of similarity in performance between moulded and machined articles. Hence the improved properties of Nylatron G.S. exist primarily by virtue of the patented formulation.

Typical Wear-resistant Parts

There are now many current applications of Nylatron G.S. for the manufacture of gears, bearings, wear pads, thrust washers, cams, door slides, switch components, bearing liners and so on. Each established use of this new material has solved special problems hitherto encountered with conventional nylon or other materials. Generally, the material is used for the manufacture of any part which demands longer wear-resistant life and greater dimensional stability than is obtainable with ordinary nylon.

A NOTE ON SEMI-LOGARITHMIC GRAPHS

IT is well known that data which gives a straight line when plotted on semi-logarithmic paper satisfies the equation

$$y = a\,\varepsilon^{bx}$$

where y is plotted on the logarithmic and x on the uniform scale. The value of a may be read off from the intersection of the graph with the line $x = 0$; b is then calculated by logarithms. If the graph does not intersect the line $x = 0$ in the data involved, both a and b must be calculated by logarithms.

The following method is proposed for the determination of b from the graph independently from a, and also for the determination of a from b if required. It is based on the measurement of the increment of x required to produce one cycle of y, e.g. 1 to 10, 10 to 100, and is independent of the choice of units for the axes.

The equation

$$y = a\varepsilon^{bx}$$

leads to

$$\log y = \log a + bx \log \varepsilon,$$

which is of the form

$$u = mx + c$$

where

$$u = \log y \quad m = b \log \varepsilon \quad c = \log a$$

To find b, we take one cycle of y from any starting point and read off the corresponding value of x (see Fig. 1), so that

$$b = \frac{\log y_2 - \log y_1}{(x_2 - x_1)\log \varepsilon} = \frac{\log \frac{y_2}{y_1}}{\Delta x \log \varepsilon} = \frac{\log 10}{\Delta x \log \varepsilon} = \frac{2{\cdot}3}{\Delta x}$$

If the range of the graph does not cover one cycle, we determine x for $y = \varepsilon$ and $y = 1$ (see Fig. 2).
Then

$$b = \frac{\log \varepsilon}{\Delta x \log \varepsilon} = \frac{1}{\Delta x}$$

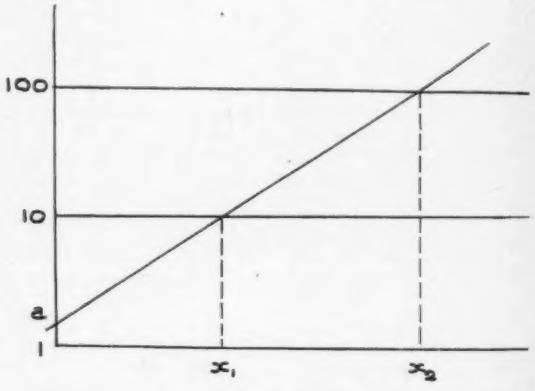
The sign of b is positive if the graph has a positive slope. If a cannot be determined at $x = 0$, it can be obtained by finding y for some convenient value of x, such that

$$bx = \text{some integer } n$$

Then

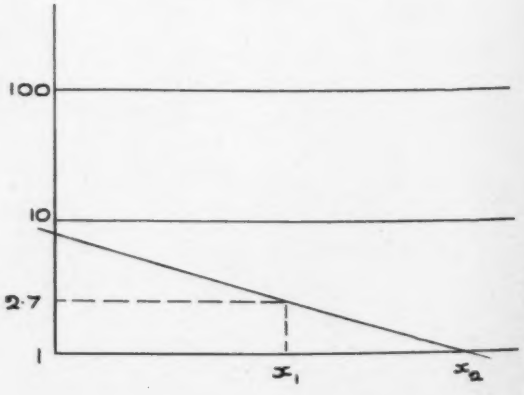
$$a = \frac{y}{\varepsilon^n}$$

The method described is applicable to slide-rule work. The value of b can always be determined from the graph regardless of a.



$$b = \frac{2{\cdot}3}{(x_2 - x_1)}$$

FIG. 1



$$b = \frac{-1}{(x_2 - x_1)}$$

FIG. 2

Submitted by P. G. Morgan, lecturer in mechanical engineering at the University of Manchester.

DESIGNING WITH THERMOPLASTICS

It is not the author's intention here to teach a course in design, but to show that with a knowledge of how to use reliable engineering data on thermoplastics, the designer is able to remove most of the "guess work" from plastics design

by R. L. MILLER*

SOUND engineering design can be used on materials of construction having properties predictable over a wide range of environmental conditions. With the advent of thermoplastics such as Delrin† acetal resin and Zytel nylon resin, of which the physical properties have been thoroughly determined and which approach those of the non-ferrous metals, engineering design techniques can also be used effectively with these plastics materials to obtain optimum performance and cost reduction.

The elements comprising good thermoplastic design, while very similar in general to those for metals, require the designer to have adequate knowledge of not only the physical or structural behaviour of the plastics, but also of how the plastics can be processed and, equally important, of how the plastic can be assembled with mating parts. Appearance, wear, toughness and chemical resistance will also have their influence on the design or selection of material for the part.

In the following pages the three important areas of structure, processing, and assembly, and how they are used in the design of thermoplastic products, are examined in detail.

*E. I. Du Pont de Nemours & Co., Del., U.S.A.

†*The following Du Pont trademarks are used throughout this article: Delrin, acetal resin; Teflon, fluorocarbon resins; Lucite, acrylic resins; Butacite, polyvinyl butyral sheeting; and Zytel, nylon resins.*

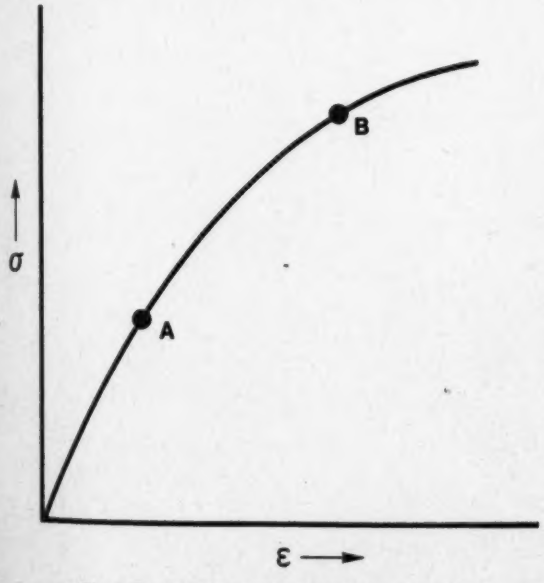


Fig. 1. Typical stress-strain curve for a plastics.

Structural Design

Structural design for plastics usually consists of calculating the amount of material needed in the "weak" or critical areas of the part to meet the loading requirements. And for the design engineer the information that is needed is found in the stress-strain relationship, which is the basic measurement of the strength of engineering materials.

A typical stress-strain curve for a plastics is shown in Fig. 1. Close tolerance plastics parts such as gears, pumps and various mechanisms require low strain or creep. For these parts a design stress must be selected which when under the influence of temperature and long time loading will not produce excessive creep or cold flow, which can cause failure. These design stresses are obtained from the lower area of the stress-strain curve near point *A*.

Some parts, however, can tolerate a certain amount of permanent distortion, for example, pressure vessels, pipe, aerosol bottles and many consumer products, and it is then more economical to use higher stresses nearer the yield strength of the material or point *B*.

Note that there is no straight section to the stress-strain curve. This is typical for plastics, although the magnitude is somewhat exaggerated here.

As strain increases, the modulus of elasticity (the ratio of stress over strain) changes (see Fig. 2). The original or tangent modulus, slope E_o, decreases with increasing strain to a "secant" modulus, slope E_s.

The secant modulus is the value used by the plastics designer in his engineering calculations. However, since

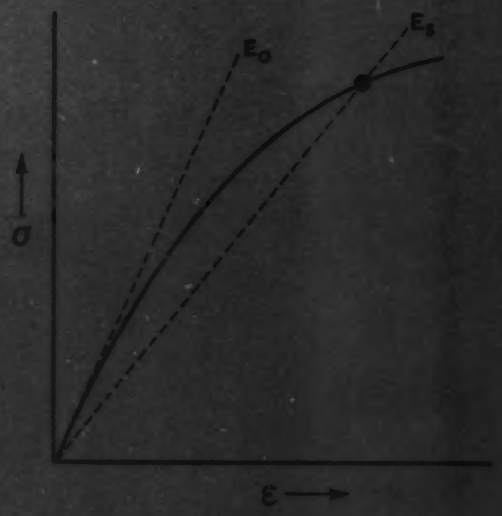


Fig. 2. Showing how the modulus of elasticity changes as strain increases.

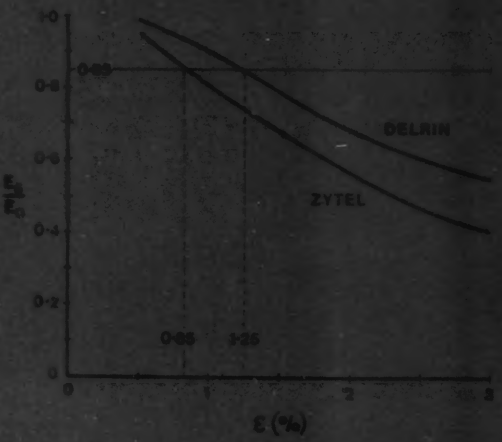


Fig. 3. Illustrating the decrease in secant modulus with increasing strain.

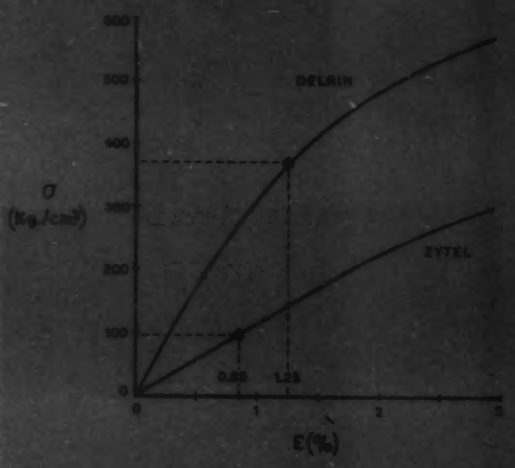


Fig. 4. Stress-strain curves at 23 deg.C.

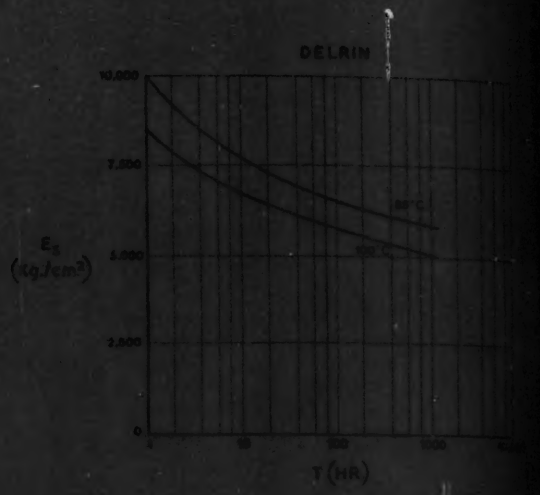


Fig. 5. Decrease in secant modulus with increasing duration of load.

COMPARATIVE THREAD STRENGTH FOR DELRIN, ZINC AND MAGNESIUM

Material	Thread type	Hole Diameter (in.)	Thread Depth (in.)	Pullout load
ZINC	1/4 in.-20 NC	0.211	0.4	6000 lb
MAGNESIUM	1/4 in.-20 NC	0.201	0.4	4000 lb
DELRIN	1/4 in.-20 NC	0.212	0.4	1400 lb

DESIGN CONSIDERATIONS FOR THERMOPLASTICS

1. STRUCTURE	Stress, Strain, Failure
2. PROCESSING	Injection Moulding, Forming, Extrusion
3. ASSEMBLY	Welding, Snap, Press Fit, Mechanical
4. APPEARANCE	Shape, Colour, Finish
5. WEAR	Friction, Abrasion, Fatigue
6. TOUGHNESS	Torsion, Impact
7. CHEMICAL	Resistance to Environment, Ingredients

	σ (Kg./cm²)		
	23° C.	50° C.	100° C.
DELRIN 500 (ε = 1·25%)	370	270	140
ZYTEL 101 (ε = 0·85%)	98	70	35

Fig. 6. Stress limits for Delrin and Zytel, at various temperatures.

most stress and strain formulae are based on the linearity of the elastic modulus, some limit to this modulus change or deviation is needed to maintain mathematical accuracy.

Fig. 3 shows the decrease in secant modulus with respect to the original modulus (expressed as in the ratio E_s/E_o) with increasing strain for two Du Pont plastics, Delrin and Zytel. Note that at 3 per cent strain the secant moduli are 0·6 and 0·4 respectively of the original moduli.

It has been found experimentally that a deviation, delta E, of 15 per cent or less permits engineering formulae to be used with good accuracy. Strain limits are obtained then at the 0·85 line (15 per cent change). For Delrin the strain limit is 1·25 per cent; for Zytel 101 with average water content, it is 0·85 per cent.

It is important to note that these curves are essentially constant at any working temperature. This is to say that the 1·25 per cent strain limit for Delrin represents not only the 15 per cent change in modulus at 23 deg. C., but also at 50 deg. C., and 100 deg. C. Thus this strain limit can be used by the designer as a basic parameter of the plastics.

To illustrate the stress which these strain limits will permit the designer to use in his calculations, the stress-strain curves for Delrin and Zytel at 23 deg. C. are given in Fig. 4. For Delrin a design stress of 370 kg./cm.² (5,300 p.s.i.) can be used; for Zytel, about 98 kg./cm.² (1,400 p.s.i.).

The 23, 50 and 100 deg. C. values are shown in Fig. 6. At 100 deg. C. the stress limit for Delrin is 160 kg./cm.² (2,300 p.s.i.), and for Zytel is 55 kg./cm.² (800 p.s.i.).

The length of time the part is under load also has an adverse effect on the design stress than can be used, due to the tendency for the plastics to creep.

The decrease in the secant modulus of Delrin with increasing duration of load for two temperatures, 85 and 100 deg. C., is shown in Fig. 5—time is in hr., the modulus in kg./cm.². These moduli curves, showing the effects of temperature and time, give the designer the structural X-ray picture of the plastics.

To examine how the designer uses this data for determining a design stress, assume that the plastics part in question is a heater blower for an automobile, operating intermittently for 10 hr. duration at a temperature of 85 deg. C. The secant modulus for Delrin at 85 deg. C. and 10 hr. is about 7,600 kg./cm.² (110,000 p.s.i.). Multiplying this modulus by the strain limit for Delrin, 1·25 per cent, a design stress of 97 kg./cm.² (1,400 p.s.i.) is obtained.

The designer can run through his calculations using this value, and solve for the required thicknesses at the critical areas in the hub and blade. A slight safety factor is sometimes applied.

Processing

The processing of plastics is another important field of consideration for the plastics designer. It is his responsibility to design his product so that it can be processed, for example moulded—and moulded as easily as possible. He should be familiar with the design of injection moulds.

Such items as: moulding tolerances; undercuts; parting lines; voids, sinks and flash; gating; drafting and knockouts; ribs and bosses; and cores and slides, should be familiar terms to him, as they can have an influence on his final design.

Assembly Techniques

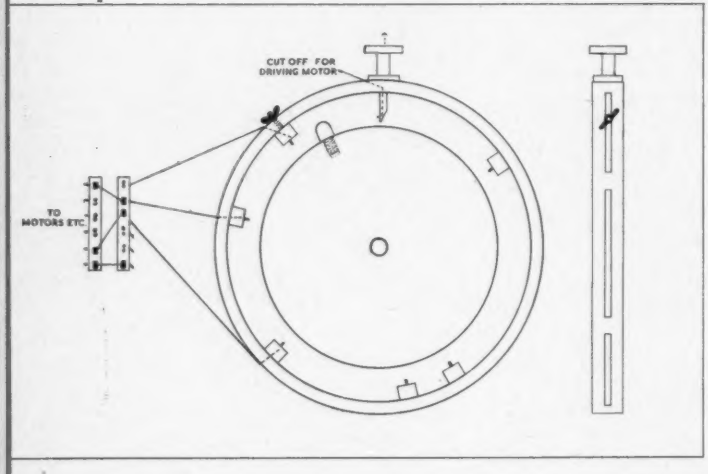
Techniques of assembly are extremely important to the designer, because it is often through the assembly methods that are possible with plastics that substantial savings are realized. One assembly operation may be extraordinarily fast, or another may permit the elimination of parts such as gaskets, bolts or threads.

PROBLEMS IN DESIGN

Problem No. 18 (April): In a sequence timing device, six microswitches are operated by a small motor-driven timer using a reduction gear. On depressing the motor starter button, each microswitch is operated (on-off) for approximately 1 second, all six switches being operated in one cycle, but not necessarily in the same order. Thus for one programme the order could be 1, 3, 6, 5, 4, 2—for another it could be 6, 1, 3, 2, 4, 5—and so on. At the termination of the cycle, which would be completed in 1 minute, the timer would switch itself off and await the next manual resetting by the operator.

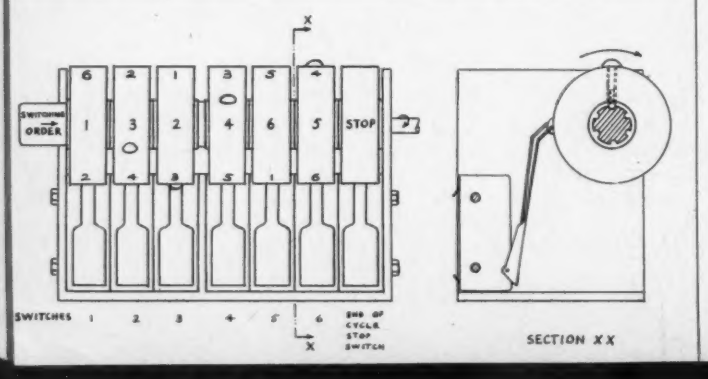
Devise a simple mechanical device to achieve the above conditions. The microswitches can be arranged in a circle or in line as desired.

There are a number of criteria by which the entries for the above problem can be evaluated. These can be divided into those ideas which concern function, i.e. ease of setting, visibility, etc.; and those ideas which can be considered from the standpoint of ease of manufacture. If only one timer were required for a test rig then something cheaply and easily made would be indicated. On the other hand the timer might be required in quantity, and designed in such a way that, with minor modifications, it could be tooled up for mass production. Lastly, there might be required a piece of equipment, built regardless of cost, in which the whole emphasis was on the user function, i.e. great speed and ease of changeover of the order of switching with little possibility of error by the operator. We were gratified by the number of entries received, which ran the whole gamut of possibilities from the very simple to the comparatively complex. In the ensuing paragraphs we shall endeavour to evaluate a selection of the entries according to the above criteria.



M. Rowland
A simple solution using wander leads and a plug rack.

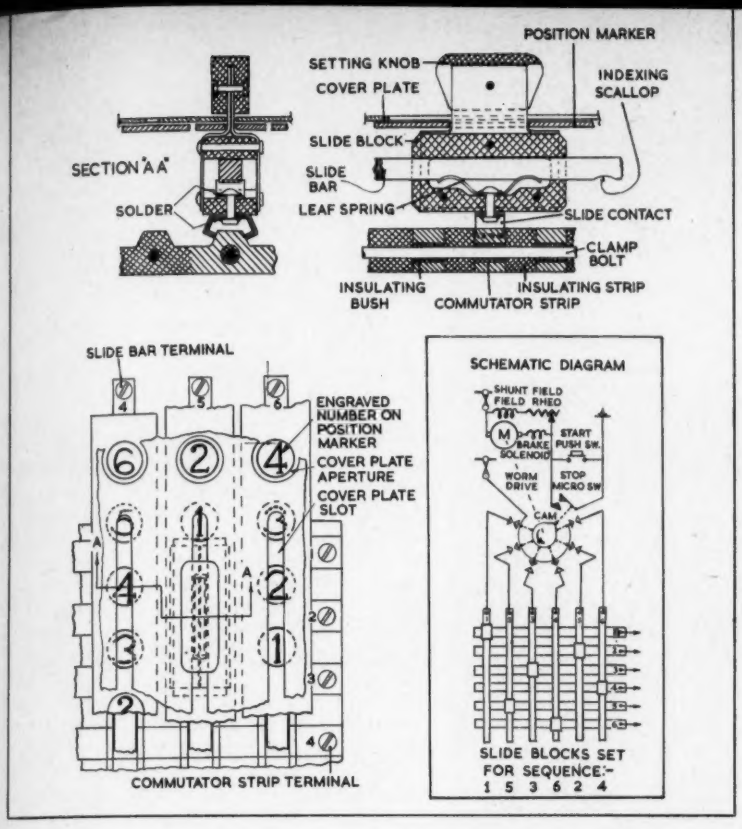
J. B. Holt
Co-axial cams positioned on splined shaft by spring-loaded detent.



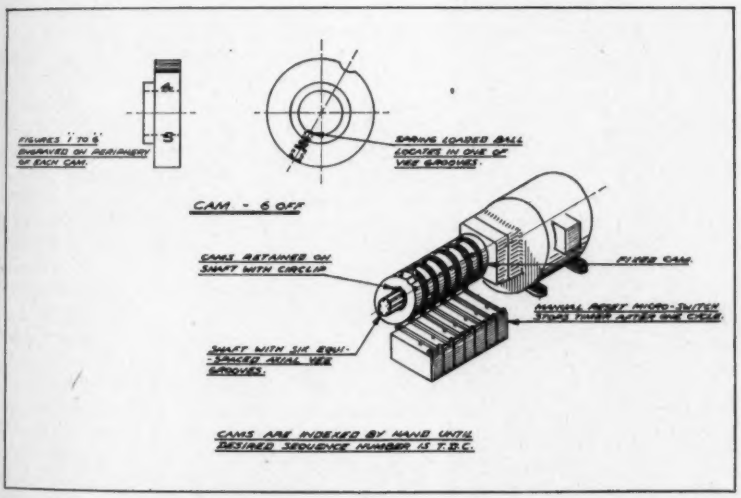
Perhaps the simplest entry, suitable for a one-off experimental rig, is that from **M. Rowland.** His sketch is diagrammatic only, but shows the principle. A disc, attached to a motor whose shaft revolves at 1 r.p.m., carries a projection which in the "off" position abuts against the motor switch which is operated by raising a knob momentarily. The microswitches are then operated in turn. They are mounted in a circular slotted rack around which they can be moved to provide variable time intervals between switching operations. This provision, however, is not a requirement of the problem as set. The order of switching is decided by the electrical method of using wander leads and a plug rack.

Then there is the rather more refined version of the same basic idea from **H. T. E. Hone.** Here again six radially arranged contacts are made in turn, and the impulses from these are fed to six slide bars and from thence to the output leads in the desired sequence. The pre-set position of each slide contact determines the order in which the commutator strips are fed. The seventh microswitch cuts the motor circuit at the end of the cycle. As in the entry from Mr. Rowland, re-starting is achieved by actuating a starter button. Mr. Hone has devoted most of his ingenuity to providing a clear indication of how he would arrange his slide bar mechanism. For rapid re-arrangement of sequence it seems to be a thoroughly feasible scheme, although rather dear to make for a "one off".

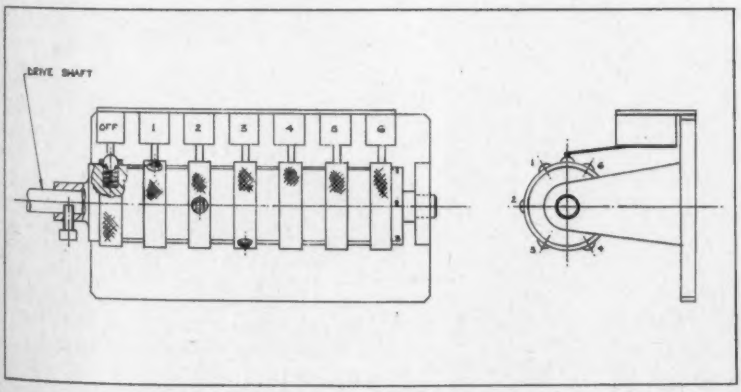
The type of entry of which the largest number were received employed a series of identical cams, mounted on a common shaft driven by an electric motor at the required 1 r.p.m. The methods of changing the switching order, however, differed in detail. In most of the entries of this kind it is necessary for the operator to turn the cams against the restraint of a spring loaded ball or plunger detent, in a series of clicks, until the desired position is reached. Typical of this type of entry are those from **J. B. Holt, R. E. W. Baker** and **A. Elkin,** and a rather better one from **J. F. Jackson.** We consider Mr. Jackson's entry to be superior in that the diameter of the knurled rings for changing the sequence order is larger than the cams, and would make for easier movement. Our only criticism is that he has chosen the wrong kind of microswitch for this kind of operation. A rather more positive arrangement, to free the cams completely during the changing operation, came from **O. W. Bews,** who uses a long key which carries a series of projections. Each projection holds a cam by means of one of six keyways. On sliding the key to the right all the cams are free to be rotated, on moving it to



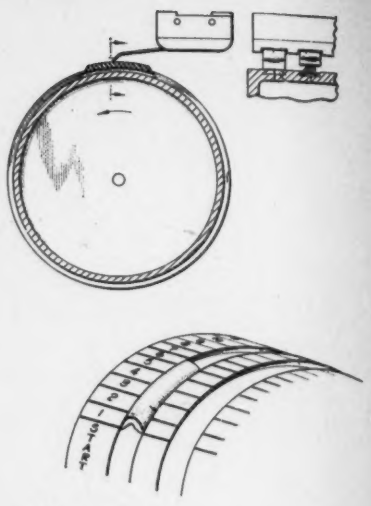
H. T. E. Hone
Switching order is determined by the position of the slide blocks on the slide bars.


FIGURES '1' TO '6' ENGRAVED ON PERIPHERY OF EACH CAM
SPRING LOADED BALL LOCATES IN ONE OF VEE GROOVES
CAM - 6 OFF
CAMS RETAINED ON SHAFT WITH CIRCLIP
FIXED CAM
SHAFT WITH SIX EQUI-SPACED AXIAL VEE GROOVES
CAMS ARE INDEXED BY HAND UNTIL DESIRED SEQUENCE NUMBER IS T.D.C.

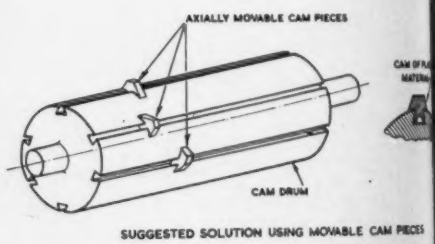
R. E. W. Baker
Another version employing co-axial cams and spring-loaded detents.



A. Elkin
Six spring-loaded balls, in each cam, are retained by a movable ring which permits only one ball to project at a time and act as a cam.

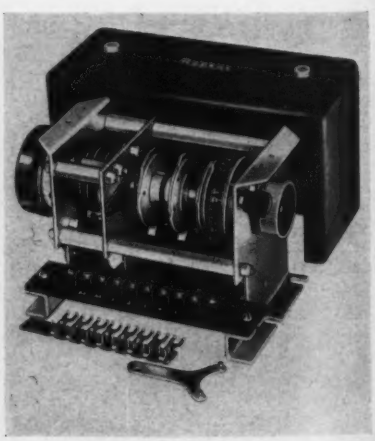


R. G. Whitaker Ltd.
An interesting timer using frictionally-held movable plastics cams held in dovetail grooves.



SUGGESTED SOLUTION USING MOVABLE CAM PIECES

Editorial suggestion borrowing the Whitaker idea, but using longitudinal grooves in the timer drum.



D. Robinson Ltd.
The Varicam timer, which could be supplied to suit the application, and in addition enable switching periods to be varied.

the left all the cams are positively held. A ball catch is used to retain the key. Mr. Bews has unfortunately omitted a seventh cam for switching off the motor.

A. Gordon's idea of using a ratchet is sound, although we are rather dubious about a rubber one. A spring-loaded roller-type freewheel of the kind described in the feature "Freewheeling Devices", in our June and July issues, if positioned at the centre of each cam, would enable setting to be carried out by rotating each cam in the opposite direction to that of the camshaft. This would be easier than overcoming the resistance of spring-loaded detents.

It may be of interest to readers to take note of two kinds of timer, available commercially, which could be used for this kind of application. The Varicam Timer, one of the well known Rodene range manufactured by D. Robinson Ltd., is a continuously rotating timer that can be provided with a cam connected so that the camshaft completes one revolution and then stops until the supply is re-initiated. The pin spanner shown in the foreground is held in place by the small knurled knob on the right-hand frame. The cams are adjustable for dwell period and also for point of operation in the cycle. Each cam can be turned against the frictional restraint of a "torque limiter" which slips at a proper amount above the drive torque to permit this, but without damage to the drive. For this application, of course, the double construction of the cams would not be necessary.

Then there is the interesting timing device produced by R. G. Whitaker Ltd. This is employed in their dry-cleaning machines, and is designed to facilitate control of the length of various cycles in the dry cleaning operation. The timer consists of a slowly rotating drum which carries a series of cams made from plastics material. The cams are fitted in slightly dovetailed circumferential grooves in the drum, and are made of resilient material which enables them to grip the grooves sufficiently to operate the micro-switches, and yet be moved around the drum to vary the cycle times. This idea could be used with rather smaller cams than that shown in the illustration. Our own suggestion, which borrows the dovetail groove idea, would position the cams in *longitudinal* grooves, six of which would traverse the length of the single timing drum. Alteration to the switching order would merely involve sliding the cams along the drum to the right positions (see inserted sketch).

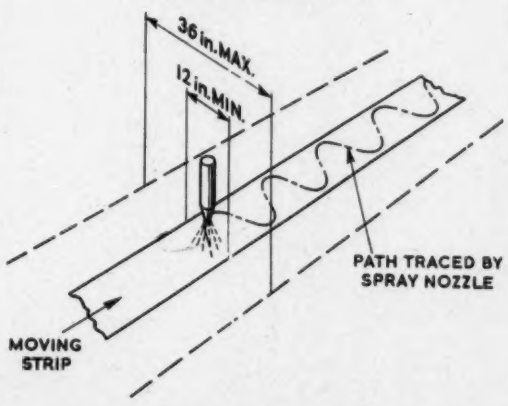
Lastly we include a much more elaborate entry from **John Tindale,** which although a costly affair to make, might be the kind of thing envisaged for a reasonably foolproof switching device where the whole emphasis was on rapid changes in switching order by a semi-skilled operator. This consists of a keyboard, a translatable platform upon which are mounted six microswitches, and a driving system incorporating a Geneva Star wheel. The keyboard has thirty-six keys, six keys being allocated to each switch, so that, by pre-selection, any switch can be given any order of sequence. Torpedo-shaped interlocking slugs prevent any two co-ordinate keys being depressed at the same time and, after the selection of any particular sequence for a particular switch, no one switch can be given two operations per cycle nor can two switches be given the same sequence. A further row of keys is arranged, one for each switch, which allows the re-selection of a sequence in the event of a wrong one being made. By pressing this release key, the catch plate which has held a depressed key is thrown back.

When the cycle is completed by the movement of the platform, the last operation is for the translatable switch platform to bring the cams into contact with all the catch plates, thus releasing all the keys which have been depressed so that when the switch platform is released at the end of its stroke it flies back to its initial position unhampered by depressed key stems. When the released platform arrives at its initial position it switches the motor off by striking the start-stop switch. Mr. Tindale's idea would seem to form the basis for some sort of signalling device, perhaps for a calculator or remote indicator. Comments are invited.

John Tindale
A more elaborate entry having a translatable platform carrying six microswitches and key operation.

PROBLEM IN DESIGN No. 22

Here is this month's problem



In a special purpose machine for the continuous production of strip material, it is necessary to provide a means whereby a spray nozzle can be slowly reciprocated across the travelling strip material to provide a coating of reasonably even thickness. The material, however, varies in width from 12 in. minimum to 36 in. maximum.

Devise a simple mechanism which will enable the amplitude of lateral reciprocation of the spray nozzle to be varied, while running, within the above limits. The speed of the nozzle is to be constant at approximately 20 ft. min. (The mechanism for varying the speed of the strip need not be shown.)

Best solutions to "Problems in Design" are published and paid for. Send your solution for this month, with a drawing or diagram (in Indian ink and not more than 12 × 12 in., please!) to the Editor, "Problems in Design No. 22 (August)". Closing date September 20.

Fig. 1. Thermal fusion of plastics pipes. (Wavin Pipes Ltd.)

PART 1: SURVEY OF PIPE COUPLINGS

With the advent of higher pressures and temperatures in engineering, it is important to choose the right pipe coupling. In the first section of his article the author describes the various types available

by A. H. ROACH

THE selection of the correct coupling for a specific application in a piping system is of paramount importance if the endless trouble and expense due to poorly constructed joints is to be avoided, and it is hoped that this survey will contribute to that end. In this sense therefore, it will be appreciated that the advice of the manufacturers should be sought in cases where severe conditions obtain, or where the effect of the conveyance of the medium is in doubt.

Compression

The compression type of coupling has supplanted the soldered or screwed types in many fields, largely on the grounds of labour economy as the joints can be efficiently assembled by unskilled labour. It has an advantage over the soldered joint in that the temperature range is not so restricted, and it also allows the use of lighter gauge tube than is required for screwed joints. Where low pressures prevail, the metal to metal joint, using a brass or gunmetal body incorporating a tapered nipple which is inserted into the preflared end of an annealed copper tube, is perfectly satisfactory. This coupling is used mainly for copper tube up to 16 s.w.g. with a maximum diameter of 2 in., but it should be remembered that a compression coupling nut for 1½ or 2 in. dia. tube requires a spanner of about 2 ft. shaft length for tightening, thus needing considerable space.

If non-injurious to the medium carried, a slight smear of jointing compound in the tube flare will serve to correct any slight imperfection of the surface. Correct alignment is essential when using this soft tubing. Similar conditions may be met using semi-hard tube with a raised annular ridge and slight taper on the tube end. Tightening of the securing nut on the ridge, combined with the ensuing pressure on the tapered end, provides an effective seal (see Fig. 2). Suitable swaging tools are available from the manufacturers.

Tube manipulation may be avoided by selecting a coupling which has an internal shoulder against which the tube abuts. Sealing is effected by tightening the backnut which compresses a ferrule on the outside of the tube against the internal cone end of the body (see Fig. 3). In similar designs, the incorporation of an anti-friction washer prevents any tendency of the tube to twist whilst the nut is being turned. Excessive tightening may easily result in deformation of the tube, and to reduce this risk it is advisable to mark the nut so that the degree of torque is readily visible.

Hubbed flange connections are provided for the larger tubes of 3 to 6 in. bore, the flared tube ends being compressed on to an olive. The flanges are equipped with dowel pins to ensure alignment and a straight pull-up.

The "bite" type of coupling (see Fig. 4) is worthy of serious consideration when designing for high-pressure hydraulic or gas purposes, whether copper or steel tubing is being used. The essential difference between this and other compression couplings lies in the sealing ring design. On closure of the nut, the ring cuts obliquely into the outer tube wall to a depth controlled by a lip on the ring. Inequalities on the tube surface are thus obviated, and the slight ridge of metal raised by the cutting action of the ring adds to the sealing qualities of this fitting. A further function of the sealing ring is that it constitutes a very effective spring washer between body, tube and nut—an obvious advantage when prolonged vibration under heavy pressure is contemplated (copper tubing is not recommended for this latter application, owing to work hardening of the metal under vibration leading to possible eventual fracture). Where copper tubing is used, minimum wall thicknesses are 16 s.w.g. up to ½ in. o.d., and 12 s.w.g. up to 2 in. o.d. Brass couplings will accept up to 6,000 p.s.i. hydraulic working pressure, and mild or stainless steel up to 10,000 p.s.i. Gas pressures of up to 50 per cent of the equivalent hydraulic pressures are usually permissible. It must be appreciated that these pressures apply to the couplings only, thicker gauges of tubing being selected as pressures and operating conditions become more severe. The steel couplings operate at a maximum temperature of 340 deg.C.

Where it is undesirable to cut into a tube wall, a collet-type steel coupling incorporating a sealing ring may prove more suitable, particularly on thin-wall tubing. The backnut forces the collet and sealing ring into a recess machined in the body for its reception. Extended wrench shafts are unnecessary for tightening this coupling.

A more elaborate manipulative coupling is one which incorporates an O ring, and that has been accurately preformed by oil pressure to an expanded diameter which gives a close fit in the appropriate part of the fitting (see Fig. 5). Clamping is effected by tightening the nut on to a conical bulge in the tube obtained during the forming process. These fittings are suitable for pressures of up to 5,000 p.s.i. at temperatures of –40 to +130 deg.C., and are equally effective for thin-walled steel tubes. The maximum wall thickness is 10 per cent of the outside diameter of the tube.

Many compression couplings have been adapted by their makers for effecting joints between plastics or plastics to

metal tubes. The usual method is to insert a copper sleeve into the tube to provide the internal support particularly necessary with normal gauge polythene tube, these sleeves assisting appreciably in the correction of any deformation of the tubes due to coiling. Owing to the greater wall thickness of polythene tube, a size larger fitting is required than would be used for the corresponding nominal bore in metal tubes. Where a discrepancy exists on the o.d. of the tube to its fitting, the fitting being larger than the tube, this condition can be rectified by immersing the tube end in boiling water for 1 to 5 min., and then expanding it to the correct diameter by inserting the sleeve immediately on removal. The joint must not be tightened until the tube is cold.

Although heating of the tube end may be accomplished by the use of a blowlamp, it is well to remember that polythene is an excellent heat insulator, so that the application of a naked flame incurs the danger of melting the outer surface without the tube being generally heated. Specially designed couplings for use with polythene tubes have however been developed, and the nominal size fitting suits the tube of the same nominal size. These fittings are of the non-manipulative type but still include an internal tube-sleeve. Hand tightening of the nut until no further movement is possible is recommended by the makers.

Capillary

Two types of coupling in the capillary category are generally recommended by manufacturers today, for use with either fully annealed or half-hard copper tube. They are suitable for water pressures of 200 p.s.i. at ambient temperatures, 75 p.s.i. at 120 deg.C., or saturated steam at 50 p.s.i. Couplings of the pre-tinned socket type are most economically joined to the tube by the use of solder paint, and the application of heat by blowlamp. Care should be exercised, when a capillary and screw female union coupling is being employed, that the solder paint does not run through to the threads when heat is applied. The second type incorporates sufficient solder in an annular recess to make a satisfactory joint (see Fig. 6). After heating, evidence of successful capillary action is the appearance of a ring of solder at the ends of the fitting.

Unions

The use of unions in pipe lines affords a simple and compact method of installation which can be broken down and easily re-assembled as required. They may be designed for use with a gasket, in which case a lipped flat seating is provided, as for metal to metal contact with cone ground seatings in either ferrous or non-ferrous metals.

Malleable iron unions, normally confined to temperatures below 260 deg.C., are suitable for steam, gas or oil at 150 p.s.i., and water at 200 p.s.i.—sizes range from $\frac{1}{4}$ to 6 in. nominal bore. Rather higher working pressures are claimed by some manufacturers—600 p.s.i. for water, gas, oil or air, and 300 p.s.i. for saturated steam. A useful union in this material has spherically ground seats which allow a joint to be made with the pipes at any angle up to 6° from centre (see Fig. 7). This adaptability could be of particular value in a restricted space where a bend is undesirable, and could obviate the danger of overstraining an ordinary union nut in an attempt to obtain alignment. Sizes in this type are $\frac{1}{4}$ to 3 in. nominal bore.

Cast gunmetal unions up to 3 in. dia. are capable of withstanding pressures of 250 p.s.i. at 200 deg.C. It is of course necessary to exercise care in the selection of pipe to be screwed, in order to avoid weakness at the joint, the minimum wall thickness for copper tube being 16 s.w.g. Special gunmetal or bronze unions are obtainable for such mediums as acid and sea water.

For higher pressures and temperatures it becomes necessary to use steel fittings of similar design, with either cone or spherically-ground seatings of bronze, steel or stainless steel. These unions are usually manufactured in three grades of forged carbon steel, i.e. normal carbon steel; that containing $\frac{1}{2}$ per cent molybdenum; and the higher grade containing 5 per cent chromium and $\frac{1}{2}$ per cent molybdenum. These grades are again divided into three classes, details of which may be found in BS 2561. In the austenitic steels the pressure and temperature range reaches 2,000 p.s.i. at 425 deg.C., and 700 p.s.i. at 590 deg.C. At temperatures of 510 deg.C. and above, consideration should be given to scaling due to oxidation. Unions are screwed in either BS Taper or A.P.I. threads from $\frac{1}{8}$ to 4 in. dia. The heavy forged high-tensile carbon steel "wing" or "handle-bar" unions are designed for rough usage and severe conditions. Constructed with spherical seats and Acme threads, they are intended for service with oil, water, mud, steam or air at non-shock pressures of 3,000 p.s.i. in 1 to 4 in. bores, normally in size increments of 1 in. (see Fig. 8). One type incorporating O ring sealing is rated at 5,000 p.s.i. non-shock—their weight should be noted: a 1 in. bore fitting weighs 4 lb., while a 4 in. weighs 46½ lb.

Worthy of mention at this stage is a simple and efficient means of sealing screwed joints with p.t.f.e. tape. A layer of this tape is laid tightly around the male thread, and owing to its low coefficient of friction the joint can easily be tightened. The seal is inert to almost all chemicals, and is effective over a wide pressure and temperature range.

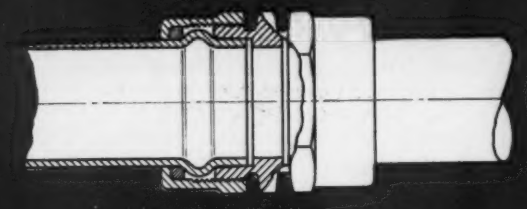
Steel unions with socket ends for welded joints are made in similar sizes and for similar ratings as the screwed types, while fittings for use with copper tubing are manufactured from a brazing metal alloy with a high copper content. Welded joints have the advantages of comparatively light weight, small spacing between pipes, simplification of insulation, and in many cases lower installation costs. The limiting circumstances, however, cannot be overlooked, i.e. in locations where the use of a welding torch may introduce the hazard of fire or explosion, or where valves or other devices which need periodic removal are used.

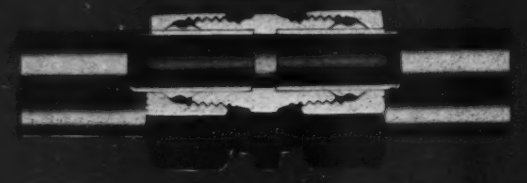
Couplings for Flexible Pipes

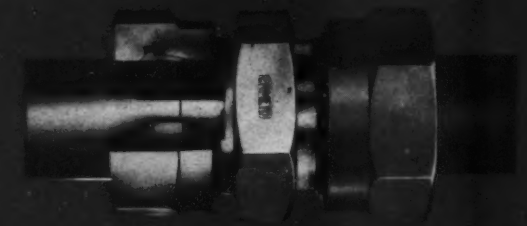
Many kinds of flexible pipe, complete with any desired type of coupling, are supplied as assemblies by the manufacturers, some of whom furnish them for specific purposes as standard items. One of these, for refrigerants such as ammonia, methyl chloride, etc., is rubber lined, and with a high-tensile steel braid outer cover will remain flexible at –55 deg.C. The couplings are of steel or brass, the end of the pipe being trapped between an outer sleeve and a serrated insert which culminates in a ground cone nipple and nut.

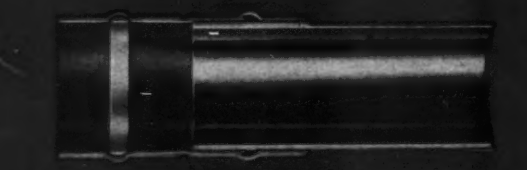
Single or double high-tensile steel wire braid reinforcing on the appropriate lining, together with a coupling designed to ensure a positive grip and efficient seal, are used for higher pressures and temperatures. Coupling designers follow roughly the same line, that of clamping the slit lining or braid into a circumferential slot in the insert, and compressing the outer portion of hose between insert and outer sleeve. These assemblies are capable of withstanding hydraulic pressures of 6,000 p.s.i. at $\frac{3}{32}$ in. bore and 1,000 p.s.i. at 2 in. bore, and temperatures of –40 to +150 deg.C. if the double reinforcing is used.

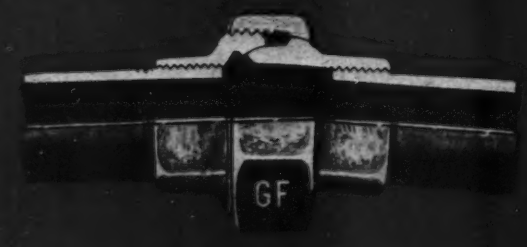
The inner linings are varied to suit the medium to be carried, but are usually natural rubber, neoprene, Hycar, butyl or p.t.f.e. Consultation with the manufacturers is recommended where any doubtful situation arises regarding the operating fluid or intended location. Minimum bend radius is an important factor in planning a circuit layout, and it is essential that the figures quoted by the makers are strictly followed. In selecting the type of coupling to be used, whether straight, banjo, elbow or tee, it should be borne in











mind that the installation should be designed as far as possible to avoid any torsional or tensile loads, or a situation which would occasion a bending moment about the end fitting. A union or flanged type of swivel coupling will do much to obviate this latter condition. It must be appreciated that continuous use of a flexible hose at maximum pressure and temperature will inevitably shorten its life, and also that running a hose in close proximity to a high heat-radiating surface should be avoided.

The elimination of spigots, tail pieces and clips is a feature of a flexible wire-reinforced rubber hose, which is used mainly for the conveyance of abrasive materials, chemicals and foodstuffs. The coupling is of the flange type, but is in two halves, each being grooved to fit over a metal ring embedded in the hose end. The flange halves are clamped together either by bolts or toggle.

Where temperatures are elevated to the region of 400 deg.C., the seamless convoluted stainless steel hose has been proven in the aircraft and gas turbine industries. In this case the end fitting is secured by swaging, and sealed by induction brazing. The connection is by means of a union with spherical nipple and swivel nut, in sizes ranging from $\frac{1}{4}$ to $1\frac{1}{4}$ in. bore.

Plastics

Owing to the appreciable variation in the composition of plastics pipes and couplings, it is desirable that the components be of the same, or a stronger material. This will ensure the properties and performance of the installation being consistent. Polythene is not recommended for sustained temperatures exceeding 20 deg.C., and it should be remembered that the high coefficient of expansion of this material must be provided for if the fittings are to escape working conditions in excess of the safe maximum pressure ratings. High-grade polythene fittings, however, are stated by the manufacturers to sustain working temperatures of −30 to +50 deg.C. Methods of joining pipes include solvent welding, fusion, welding, screwing, compression coupling or flanged coupling.

Pre-flaring the tube ends and tightening on a polythene olive by means of a nylon backnut is a method of coupling by compression favoured by one maker, whilst that of another is to insert a plastics collar which raises an external bulge on the tube, and on which the nut is tightened (see Fig. 9). This latter operation is carried out "cold", and no wrenches should be used for closure. The use of jointing compound should be avoided.

Chemical fusion is a simple process in which a solvent is brushed on to the ends of the pipes to be joined, prior to its insertion in a plain coupling sleeve. The time for setting is dependent on the hardener in the solvent, and can range from seconds to hours.

Thermal fusion, which most manufacturers recommend for joining pipes up to 3 in. bore, is accomplished by the judicious use of a blowlamp, and a welding tool supplied by the makers. Heat is applied to the tool which holds the socket, until the correct temperature, i.e. 320 deg.C. for high density polythene, is reached, and the two components are simply pressed together until cold.

Initially the socket should be an extremely tight fit on the pipe, so that on pressing the tube into the socket after heating, any possible oxidation will be rubbed off.

In the case of pipes of 3 to 6 in. bore in heavy gauge, the physical difficulties of handling the components preclude fusion welding, and the general method of coupling is by threaded joints. It is recommended practice however to fillet weld at the point where the pipe enters the fitting, after screwing up. A welding torch which emits a stream of hot air or nitrogen is used for melting the plastics welding rod.

Flanges are obtainable either separately or pre-welded to the pipes. Care is necessary when ordering flanges, as some

makers produce them to their own standards as well as to BS standards. Lack of rigidity in plastics makes the backing ring essential if leakage between bolts is to be avoided. The working pressures quoted by producers for their high-grade polythene tubes are in excess of those specified in BS 1972. A quick-connecting coupling in polythene to suit tubes to this specification, consisting of a body with integral insert and threaded outer sleeve, requires but a turn of the nut to compress a stainless steel spring on to the tube and so effect a joint satisfactory for the conveyance of cold water, air or potable liquids. Alternative materials for this coupling are nylon or brass.

Where problems of thermal expansion exist, the possibilities of polythene expansion couplings may well be considered. Designed for both vertical and horizontal applications, they allow a movement of ± 1 in. Consisting of a female static section, with male sleeve and roller sealing rings, they commence operation at 5 p.s.i. As heat must obviously be present where these thermal stress relief fittings are required, some softening of the polythene pipes must inevitably follow, as a consequence of which they may tend to buckle. Accurate linearity then, is essential, and the attached piping must be clipped in such a manner that linear expansion is possible. Couplings are of the flanged or socket types; the latter for fusion welding. Comparable fittings in a.b.s. co-polymer or plasticized p.v.c., having marginal temperature and pressure advantages, are also available. Joining to metal pipes may be carried out by using couplings which incorporate a plastics and metal connection, or by means of adaptors.

High-density polythene pipe with an integral flange is one recent contribution to methods of coupling; this has the advantage of not being subjected to any undue heat such as may be engendered when the flange is welded to the pipe. The flange is formed from a double thickness of the pipe wall, the perimeter having sufficient clearance from the bolts of the backing flange, which is drilled to BS 10. These backing flanges are supplied in either ferrous or non-ferrous materials.

Clamp Type

As alternatives to bolted flanges, V band couplings and flanges offer high strength, lighter weight and smaller envelope. These flanges are of aluminium alloy or stainless steel with a stainless steel V or clamping band. Circumferential tightening is by one or more T bolt latch couplers.

For hot air, gas or fuel a very light coupling has been produced which has a plain metal to metal seal, and which will operate at temperatures of -18 to $+800$ deg.C. at 660 p.s.i. A progressive series of heavier design, and with gaskets, caters for service on pneumatic, hydraulic, fuel, cooling and heat transfer lines, at higher ratings in sizes from 1 to 12 in. o.d. pipe. More severe conditions with temperatures to 815 deg.C. are met by the use of thicker flanges with a "trapped" metal gasket, and a coupling of two or three segments with stud and nut fastenings. These heavy-duty couplings are in the National Pipe Standard of 1 to 8 in. with the flanges butt welded to the pipes (see Fig. 10).

Another version of the V flange connection features an outer ferrule which is ridged on its inner surface. The pipe is expanded into the ridges by means of a special tool. This wholly mechanical joint is invaluable where non-weldable aluminium alloy pipe is specified.

Expansion

The stainless steel bellows-type expansion units are well known, and are produced in B.S.P. sizes of $\frac{1}{2}$ to 72 in. Maximum working pressures are 100 p.s.i. up to 5 in. and progressively lower to 25 p.s.i. at 38 in. and larger. Units are supplied with flanges drilled to BS 10, or with pipe ends for welding, or a combination of both. Linear movement is $\pm\frac{1}{4}$ in. at $\frac{1}{2}$ in. size, and units with combined linear and lateral movement are obtainable while angular motion is accommodated by hinged units. Care must be exercised in locating the bellows unit, as its flexibility will allow a pipe to extend under pressure load, possibly damaging the bellows. To prevent this, the pipe should be securely anchored at each end of a straight run, with the unit fitted between, and with a guide to prevent sideways movement. For straight linear movement, the piston type of expansion fitting, usually in cast gunmetal or cast iron, provides a larger scale of traverse. Manufactured with either screwed or flanged connections in gunmetal, the traverse is in the range 2 to 3 in. with bores of $\frac{1}{2}$ to 3 in., while the flanged cast iron class for the larger bores up to 6 in. allows for a traverse of 3 to 4 in.

Self-sealing and Quick-release

Of the numerous types of self-sealing couplings in existence with designs to cater for specific applications, some incorporate a self-sealing valve in both fixed and free halves of the coupling. This type achieves the object of coupling or uncoupling under pressure with a minimum of spillage, and no ingress of air or foreign matter. Bayonet or screw type couplings are produced for hydraulic pressures up to 4,000 p.s.i. in either light allow or stainless steel, and in the fully connected position the free passage around the valves is equal to the full cross-sectional area of the pipe (see Fig. 11). Couplings are available for the conveyance of fuel oils, liquefied petroleum products, synthetic lubricants, coolants, etc. In the case of the two latter media, manufacturers are emphatic that their advice be sought prior to the use of these couplings on a new project.

Connections to hose are either screwed, brazed, or with a tail piece for band fastening to a variety of hose including high-pressure twin braided steel. Couplings are of course available with the sealing valve in one half only, and in a number of materials such as light alloy, brass, bronze, carbon and stainless steel. Useful, particularly on mobile equipment, is the "push-pull" quick-release coupling in sizes from $\frac{1}{4}$ to $1\frac{1}{4}$ in. bore, for pressures up to 3,000 p.s.i. Coupling or uncoupling is by hand pressure, and hose connection is by tail piece insertion fixed by outside banding.

Some of these couplings are convertible to "straight-through" units or vice versa, by virtue of easily removable valves in standardised sizes. Made of stainless steel, they are used mainly in water services, particularly on aircraft, and operate at 50 p.s.i. Normal "straight-through" quick-release couplings, in a range of materials from light alloy to alloy steel, are produced for pressures up to 11,500 p.s.i.

Rotary and Swivel

The necessity for leak-proof admission of fluids or gases into revolving drums, etc., has been responsible for the development of efficient rotary joints, which are roughly of two types, i.e. the one-way flow, and the syphon type with return flow. The one-way type is simply for the introduction of the medium into the rotating roll, whereas the return flow type incorporates a syphon tube which carries condensate from the roll through the centre of the rotary union to the outlet (see Fig. 12). Differences in design are principally in the manner of sealing. In some types the sealing ring is of a self-lubricating graphite composition, wear of which can be regulated by an adjustable header. In others the sealing is accomplished by means of mating rings, one of stainless and the other of carbon steel. The internal bellows compensates to some extent for any shaft misalignment.

Inlet and outlet connections to the union must be of flexible tube free of twist or bend. Manufacturers differ slightly in their recommendations for tube alignment. In some cases avoidance of tension and a slight curve in the direction of rotation is favoured, while in others a straight tube and the use of an elbow is recommended. Maximum r.p.m. is normally 1,000 unless specially ordered, with working pressures up to 250 p.s.i. at 200 deg.C., but above this

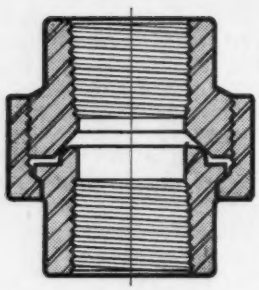


Fig. 8. Newman Hender screwed union.

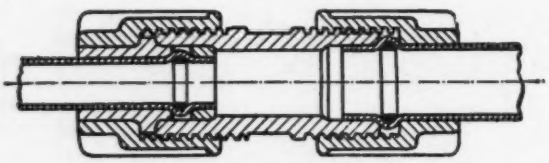


Fig. 9. Wisaplast coupling for plastics pipes.

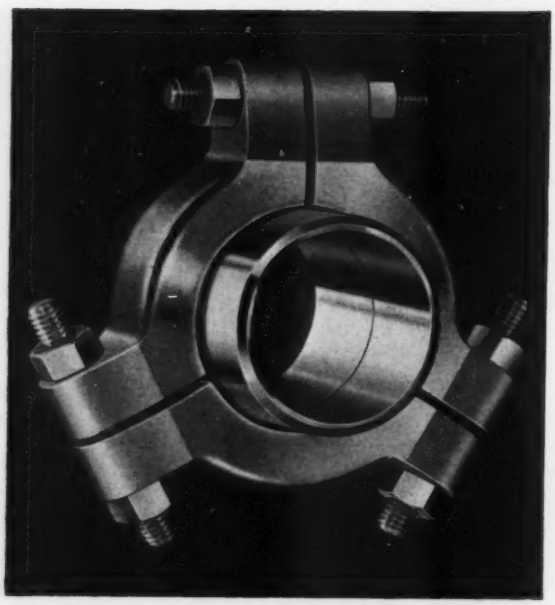


Fig. 10. Conoseal heavy-duty coupling. (King Aircraft Corp.)

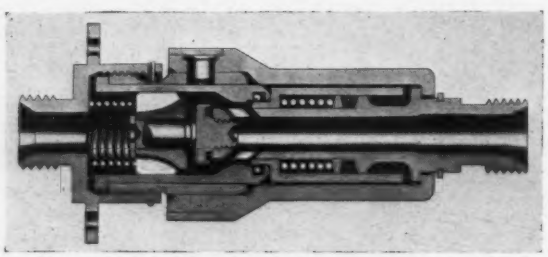


Fig. 11. Lockheed-Avery self-sealing coupling.

temperature the unions are usually provided with plain carbon bearings.

Where oscillatory or intermittent rotary action is desired, swivel joints can be used to advantage. Produced in mild steel, gunmetal or light alloy for pressures up to 4,000 p.s.i., they are suitable for such media as steam, gas, water, oil or air. It is well to note, however, that some of these fittings are for specific use on hydraulic fluid. One advantage of the swivel coupling over flexible hose is the ability to operate down to –60 deg.C. The normal functioning life is approximately two years at high pressure, after which period the seals are usually changed.

Couplings for Glass Pipes

Glass pipes having conical buttressed ends are usually joined by means of flanges of conical bore in cast iron, aluminimum alloy or plastics (see Fig. 13). The glass pipe is insulated from the metal flange by a pre-formed rubber or plastics insert, while between the two pipe ends to be joined a gasket of rubber or asbestos is employed. As the flanges compress on the buttresses before reaching the pipe ends, these are visible after the joint has been made.

Where a coupling has to be made to a lined pipe having a radiused bore at the face, the problem of ensuring a good seating on the flat portion of the lined pipe flange may be overcome either by using a glass pipe of larger nominal bore than the lined pipe, or by incorporating a glass adaptor ring. This ring will have a larger o.d. than the glass pipe, but will still be small enough to remain within the bolt circle of the flanges.

Alignment is extremely important in all couplings of this kind, and the use of a feeler gauge is recommended. Coupling bolts should be tightened evenly, but initially not more than necessary to provide a leak-proof closure. After a time lapse the inserts and gaskets will adopt a permanent set, and it is then that the coupling bolts should be finally tightened to ensure adequate joint compression. Over-tightening the bolts should be avoided, and difficulty in making the joint leak-proof is an almost certain indication that the flange faces are not parallel. Working pressures are approximately 35 p.s.i. up to 4 in. bore, although 100 p.s.i. is possible in smaller bores.

* * *

The following tables list many of the principal manufacturers and suppliers of couplings. While every effort has been made to ensure that the information presented is correct, the tables are intended to indicate only the main characteristics of particular types of couplings. The omission of any particular pressure or temperature does not necessarily indicate that the couplings are unsuitable for these conditions, but merely that the limits are dependent on the specific application and size of pipe. Reference should always be made to the relevant company for detailed information.

The following abbreviations have been used:

BSP	British Standard Pipe threads.
BSP(T)	British Standard Pipe taper threads.
ASP	American Standard Pipe threads.
ASP(T)	American Standard Pipe taper threads.
API	American Petroleum Institute Standard taper threads.
NPS	National Pipe Standard (now ASP).
UNF	Unified threads.
HP	High pressure.
LP	Low pressure.
RT	Room temperature (approximately 20 deg.C.).
I.S.O.	International Standards Organisation (metric threads).
SAE	Society of Automotive Engineers.
Dryseal	Similar to ASP(T).
Briggs	Former name for ASP system.

Where pressures are quoted in the form of maximum to minimum, e.g. 5,000 to 1,000 p.s.i., the specific working pressure is dependent on the size of the pipe given in the adjoining column. Thus, "5,000 to 1,000 p.s.i., o.d. of pipe ¼ to 3 in." indicates that the maximum pressure is 5,000 for ¼-in. pipe and 1,000 for 3-in. Intermediate pressures may be approximately interpolated between these limits.

Only the "straight" couplings have been mentioned in this survey, but in most instances the company listed also markets a similar range of T's, bends and reducing sockets.

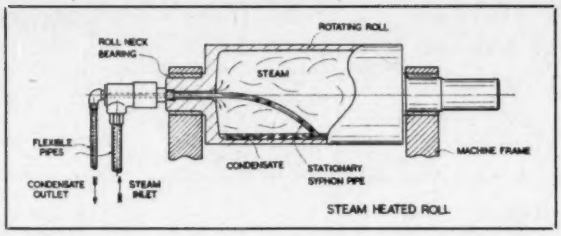


Fig. 12. Typical application of a Filton rotary union.

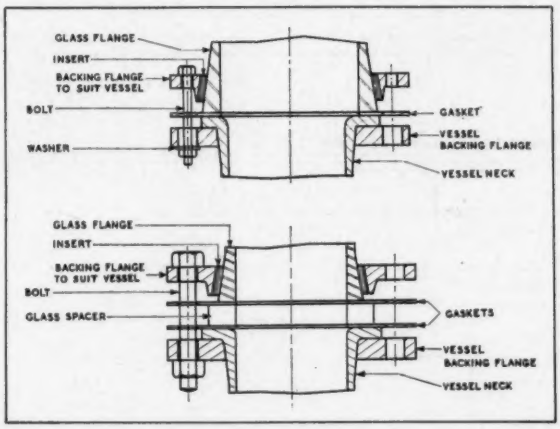


Fig. 13. Q.V.F. couplings for glass pipes.

RELEVANT BRITISH STANDARD SPECIFICATIONS

10:—*Tables of Pipe Flanges (for land use).* These tables are issued in five parts, as follows:

10, Part 1: 1947. *Pipe flanges for land use (for pressures up to 400 ft. head).*

Deals with the dimensions of flanges for pipes, valves and fittings for maximum working water pressures up to 400 ft. head (173 p.s.i.) at a maximum temperature of 100°C., and includes minimum mechanical requirements for cast iron, cast steel, bronze, wrought iron, wrought steel, and malleable cast iron pipe flanges.

10, Part 2: 1926. *For working steam pressures up to 450 p.s.i. (tables D to P).*

10, Part 3: 1929. *For working steam pressures from 450 to 600 p.s.i. (table R).*

10, Part 4: 1931. *For working steam pressures from 600 to 900 p.s.i., and temperatures up to 427°C. (table S).*

10, Part 5: 1932. *For working steam pressures from 900 to 1,400 p.s.i., and temperatures up to 427°C. (table T).*

In each case tables of dimensions for various nominal pipe sizes are given, with metric equivalents and illustrative drawings, and also bolt circle and bolt sizes.

66: 1914. *Copper-alloy three-piece Unions (for low and medium pressure screwed copper tubes).*

Deals with unions of ⅛ to 4 in. nominal size (for domestic plumbing and similar work), for use with screwed copper tubes in accordance with BS 61.

99: 1922. *Copper-alloy pipe fittings screwed for low- and medium-pressure BS copper tubes.*

The fittings dealt with in this specification are for domestic plumbing and similar work, for use with screwed copper pipe in accordance with BS 61.

143: 1952. *Malleable cast iron and cast copper alloy pipe fittings for steam, air, water, gas and oil.*

The complementary standard, for pipe fittings having BSP taper male and parallel female threads, is BS 1256.

778: 1951. *Steel pipes and flanged joints for hydraulic purposes.*

Covers steel pipes and flanged joints for hydraulic fluids such as water and oil, suitable for the following design pressures: (a) up to and including 1,500 p.s.i.; (b) 1,500 to 2,250 p.s.i.; and (c) 2,250 to 4,500 p.s.i.

1256: 1952. *Malleable cast iron (whiteheart process) and cast copper alloy pipe fittings for steam, air, water, gas and oil.*

The complementary standard, for pipe fittings having BSP taper male and female threads or API line pipe threads, is BS 143.

1387: 1957. *Steel tubes and tubulars suitable for screwing to BS 21 pipe threads.*

Applies to welded and seamless screwed and socketed and plain end tubes from ⅛ to 6 in. nominal bore.

1560: 1958. *Steel pipe flanges and flanged fittings for the petroleum industry.*

Specifies the design and construction of steel pipe flanges and flanged fittings for the petroleum industry, for classes 150, 300, 400, 600, 900, 1,500 and 2,500.

1575: 1949. *Cast iron pipe flanges and flanged fittings (class 125) for the petroleum industry.*

Material standards are laid down, and tables given containing full dimensions for all sizes from 1 to 96 in.

1576: 1949. *Cast iron pipe flanges and flanged fittings (class 250) for the petroleum industry.*

Material specifications are given, and also tables containing full dimensions for all sizes from 1 to 48 in.

1740: 1951. *Wrought pipe fittings, iron and steel, screwed BSP thread.*

Provides for an extensive range of fittings (screwed BS pipe thread) for use with wrought steel and wrought iron pipes, and includes particulars of equal sockets, hexagonal backnuts and barrel nipples as specified in BS 788 and 1,387.

1770: 1951. *Pipe flanges for use on internal combustion engines and installations.*

Covers the general and detailed construction of oval, square and triangular pipe flanges for use on systems connected with internal combustion engines, e.g., coolant systems, exhaust and induction systems and oil pipe systems.

2035: 1953. *Cast iron flanged pipes and flanged fittings.*

Deals with a range of pipes and fittings from 2 to 48 in. dia., and specifies quality, tolerances, hydraulic testing and inspection.

2051, Part 1: 1953. *Copper and alloy capillary and compression tube fittings (for use with fractional o.d. sizes of tubes) for engineering purposes.*

Lays down such dimensions and requirements as are essential to ensure satisfactory installation and performance. Applies to fittings ranging from ⅛ to 1 in., for use with fractional o.d. sizes of tubes, and includes a number of general requirements relating to design, construction and workmanship.

2051, Part 2: 1954. *Olive, soldered nipple and flared types of copper and copper alloy tube fittings for engineering purposes.*

Dealing with: (a) olive fittings from ⅛ to ¾ in.; (b) soldered nipple fittings from ⅛ to ¾ in.; (c) flared fittings from ¼ to 1 in.; and (d) inverted flared fittings from ⅛ to ¾ in.

2051, Part 3: 1954. *Steel compression pipe fittings for engineering purposes.*

Applies to two ranges of fittings: (a) for use with fractional o.d. pipes of ¼ to 1¼ in.; and (b) for use with pipes having nominal bores of ⅛ to 1 in.

2051, Part 4: 1954. *Steel nipple pipe fittings for brazing (unified threads and unified hexagons).*

Provides for the complete dimensional standardization of steel nipple fittings for brazing, in sizes ranging from ⅛ to 1¼ in., and intended for use with fractional o.d. sizes of tubes.

2561: 1955. *Forged steel pipe fittings screwed with API thread for the petroleum industry.*

Applies to forged carbon and alloy steel screwed fittings for assembly with pipes screwed in accordance with API. The range of sizes is from ⅛ to 4 in., and 6 in., and the range of ratings from 600 to 1,500 p.s.i.

2598: 1955. *Glass pipeline and fittings.*

Covers pipeline from ¾ to 18 in. nominal dia., and specifies maximum working pressures, standard lengths, and limits on ovality and on the angle between ends and axis. The fittings described and illustrated comprise seven types of bends, tees, crosses and reducers. The dimensional requirements of buttress ends and backing flanges are given in detail to ensure interchangeability.

2985: 1958. *Dimensions of carburettor output flanges.*

Specifies overall dimensions of abutment faces of single and double barrel output flanges (with clearance attachment holes), for motor cycle, automobile and industrial internal combustion engine carburettors.

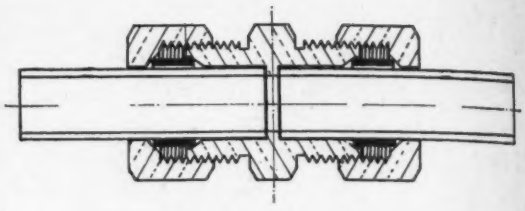
3022: 1924. *Marine flanges.*

This dimensional specification deals with flanges for marine purposes for 55, 125, 225 and 235 p.s.i., and gives the formula upon which the thickness of the flanges are based dependent upon the material and also the assumed bolt stresses.

SCREWED UNIONS

Air Automation

Type or Trade Name	Suitable for	Maximum Working Pressure (p.s.i.)	Maximum Working Temperature (°C.)	Remarks
Tube-to-tube solderless fittings	Air	—	—	$\frac{1}{8}$, $\frac{1}{4}$ & $\frac{3}{8}$ in. BSP threads suitable for pipes of $\frac{3}{16}$, $\frac{1}{4}$ & $\frac{3}{8}$ in. o.d.



Aeraspray Associated Ltd.

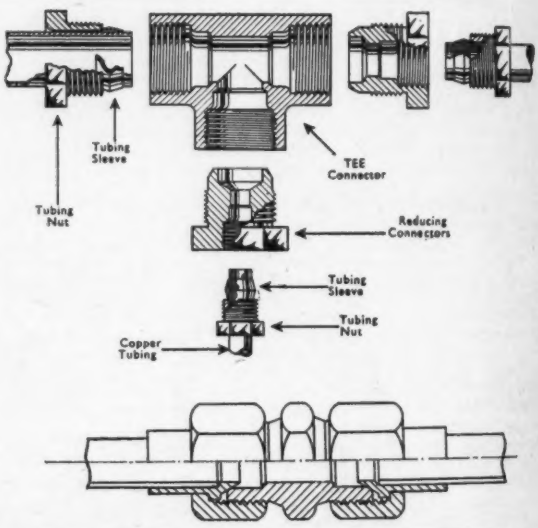
Type or Trade Name	Suitable for	Maximum Working Pressure (p.s.i.)	Maximum Working Temperature (°C.)	Remarks
Screwed unions	Air Paint Light oils	—	—	$\frac{1}{8}$, $\frac{3}{8}$, $\frac{1}{2}$ & $\frac{3}{4}$ in. BSP threads

Bell's Asbestos & Engineering Ltd.

Type or Trade Name	Suitable for	Maximum Working Pressure (p.s.i.)	Maximum Working Temperature (°C.)	Remarks
Screwed unions	—	*Steel* 500 (*non-weldable*)	482	$\frac{1}{8}$ to 2 in. BSP (T)
		Gunmetal 250	204	$\frac{1}{8}$ to 3 in. BSP (T)
		Steel 2,000 (*weldable*)	482	$\frac{1}{8}$ to 2 in. BSP (T)
		Steel 2,000 (*Bronze seated*)	204	$\frac{1}{8}$ to 2 in. BSP (T)

Benton & Stone Ltd.

Type or Trade Name	Suitable for	Maximum Working Pressure (p.s.i.)	Maximum Working Temperature (°C.)	Remarks
Enots Solderless (compression type)	Air Gas Fluids	*Brass* 4,000 3,000 4,000 600 150	—	For copper tube: $\frac{1}{8}$ to $\frac{3}{8}$ in. o.d. $\frac{1}{2}$ to $1\frac{1}{8}$ in. o.d. $\frac{1}{8}$ to $\frac{3}{8}$ in. o.d. (Bundy tube) $\frac{3}{16}$ to $\frac{1}{2}$ in. o.d. (HP hose) $\frac{3}{16}$ to $\frac{1}{2}$ in. (LP hose)
Enots Standard to BS 2051 (screwed and solder type)	Air Gas Fluids	*Brass* (as above)	—	$\frac{1}{8}$ to $\frac{3}{4}$ in. BSP threads. UNF to order.



British Ermeto Corp. Ltd.

Type or Trade Name	Suitable for	Maximum Working Pressure (p.s.i.)	Maximum Working Temperature (°C.)	Remarks
(See Fig. 4 on page 516)	Hydraulic Chemical Coolant Oil Gas Steam Water	(Hydraulic pressures quoted below. For gas applications, use 50% of hydraulic pressures)		o.d. of pipes:
		Stainless Steel 10,000	343	$\frac{3}{16}$ to $1\frac{1}{4}$ in.
		Mild Steel and *Stainless Steel* 7,500 5,000	343	$1\frac{1}{4}$ in. 2 in.

Type or Trade Name	Suitable for	Maximum Working Pressure (p.s.i.)	Maximum Working Temperature (°C.)	Remarks
		Brass 6,000 3,000 2,000 1,500	180	$\frac{3}{16}$ to $\frac{1}{2}$ in. $\frac{5}{8}$ to 1 in. $1\frac{1}{4}$ and $1\frac{1}{2}$ in. 2 in.
		(Aluminium alloy and high duty bronze to order; also fittings for metric pipe diameters with metric or UNF threads)		

Donald Brown Ltd.

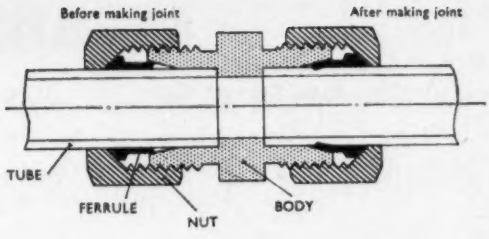
Type or Trade Name	Suitable for	Maximum Working Pressure (p.s.i.)	Maximum Working Temperature (°C.)	Remarks
Brownall (compression type)	Hydraulic Steam Chemicals Fuel oil Air Lubricant	(Hydraulic pressures quoted below. For gas applications, use 50% of hydraulic pressure) *Mild Steel* *Stainless Steel* 10,000 7,500 5,000 *Mild Steel* *Stainless Steel* 10,000 7,500 *Brass* 3,000 2,000	 343 343 343 343 343 148 148	Nominal bore of pipes: ⅛ to 1 in. 1¼ in. 1½ in. Fittings BS 1387 o.d. of pipes: ¼ to 1½ in. 1½ in. ⅜ to 1 in. 1¼ to 1½ in.
Standard to BS 864 type B (compression)	Water LP steam Air Hydraulic	*Gunmetal* 200 150 100 75 75 50	 RT 93 121 	o.d. of pipes: ¼ to 2 in. 2 to 3 in. ¼ to 2 in. 2 to 3 in. ¼ to 2 in. 2 to 3 in.
To BS 61 Pt. 2 (screwed) Table 1 Table 2	Hydraulic	*Gunmetal* 175 300	 159 159	Nominal bore of pipe: ⅛ to 4 in. ¼ to 4 in. (Fittings available with the following threads: BSP, BSP (T), ASP (T) and API)

BTR Industries Ltd.

Type or Trade Name	Suitable for	Maximum Working Pressure (p.s.i.)	Maximum Working Temperature (°C.)	Remarks
Hi-Flex reusable couplings (male and female hose connections)	Hydraulic Air Fuel oil Lubricant Coolant	*Steel* 5,000 to 1,000	−30 to +110	For hose of bore 5/32 to 2 in. (Fittings are available with the following threads: BSP, JIC, SAE, NPTF, Dryseal and Briggs)

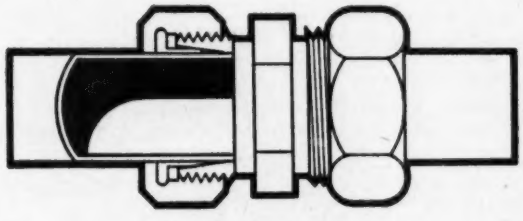
Thos. Chatwin & Co.

Type or Trade Name	Suitable for	Maximum Working Pressure (p.s.i.)	Maximum Working Temperature (°C.)	Remarks
Screwed union	Steam	*Steel* 1,000 *Steel with bronze seats* 1,000	 482 204	¼ to 2 in. BSP (T) and API threads ¼ to 2 in. BSP (T) and API threads



Compression Joints Ltd.

Type or Trade Name	Suitable for	Maximum Working Pressure (p.s.i.)	Maximum Working Temperature (°C.)	Remarks
(Compression types) Titex	Water Gas LP steam	*Brass or Gunmetal* 200 100 75	 RT 93 121	¼ to 2½ in. (copper tubes to BS 659)
Titex Senior	Water Gas LP steam	*Brass* (compression type) 150	 RT	3 and 4 in. nominal bore (copper tubes to BS 659)

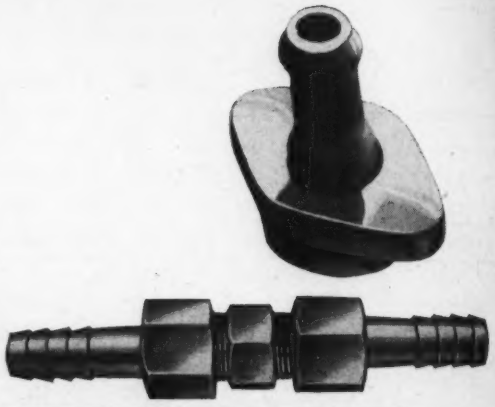


Conex-Terna Ltd.

Type or Trade Name	Suitable for	Maximum Working Pressure (p.s.i.)	Maximum Working Temperature (°C.)	Remarks
(Compression types) Conex to BS 864 type A (non-manipulative)	Water	*Brass* 200 100 75 *Gunmetal* 200 100 75	 RT 93 121 RT 93 121	Nominal pipe size ¼ to 2 in. ⅛ to 1 in.
Conexcel to BS 864 type B (manipulative)	Water	*Brass* 200 100 75 *Gunmetal* 200 100 75	 RT 93 121 RT 75 121	¼ to 1½ in. ¼ to 1 in.

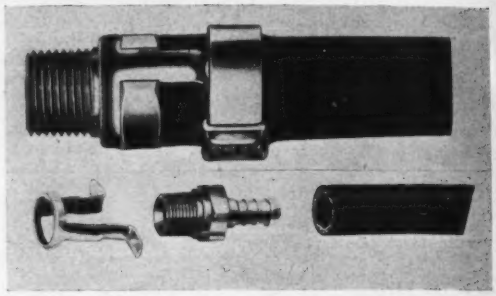
Consolidated Pneumatic Tool Co. Ltd.

Type or Trade Name	Suitable for	Maximum Working Pressure (p.s.i.)	Maximum Working Temperature (°C.)	Remarks
Hose connections Standard	Air	*Steel* 100	82	
		1 piece		$\frac{1}{4}$ to $\frac{3}{8}$ in. BSP and ASP (T)
		3 piece with union nut		$\frac{3}{8}$ to 1 in. BSP
Heavy Duty	Air	3 piece with wing nut		$\frac{3}{4}$ and 1 in.



Eltonsford Ltd.

Type or Trade Name	Suitable for	Maximum Working Pressure (p.s.i.)	Maximum Working Temperature (°C.)	Remarks
Piggyback hose coupling	Hydraulic Steam	—	—	Hose bore: $\frac{1}{4}$, $\frac{3}{8}$, $\frac{1}{2}$, $\frac{3}{4}$ and 1 in. Thread sizes in NPT or BSP (T)

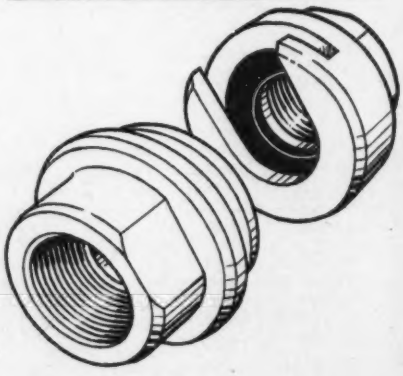


Flight Refuelling Ltd.

Type or Trade Name	Suitable for	Maximum Working Pressure (p.s.i.)	Maximum Working Temperature (°C.)	Remarks
Standard FRS 110 (flexible)	Fluids	75 (400 for special variant)	—	o.d. of pipes: $\frac{3}{4}$ to 5 in. (Drip and heat shields are available for use with these couplings)
O ring connector FRS 380 (flexible)	Hydrocarbon aviation fuels	75	—	1 to 3 in. dia.

Globe Pneumatic Engineering Co. Ltd.

Type or Trade Name	Suitable for	Maximum Working Pressure (p.s.i.)	Maximum Working Temperature (°C.)	Remarks
Hose-to-hose couplings	Air	*Steel* nipples with *brass* nuts 100	—	Hose bore: $\frac{1}{4}$, $\frac{3}{8}$ and $\frac{1}{2}$ in.
Globe coupling	Liquids Gases	5 to 350	up to 120	Sizes from $\frac{1}{4}$ in. to 12 in. bore



NEW IDEAS IN DESIGN

Outstanding products in current manufacture and awaiting development in the U.K.

Sensational Claims for New Air Compressor

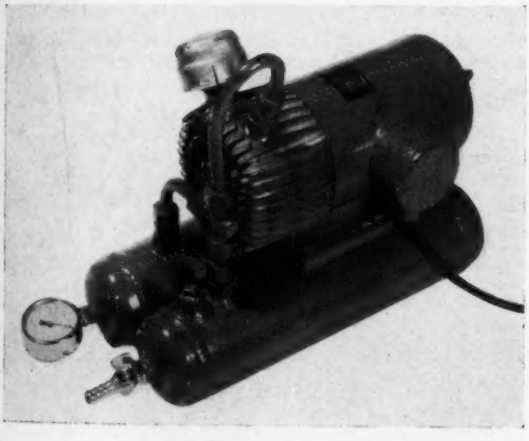
THE air compressor shown is a small version of a range recently developed in Germany by the inventor Herr Paul August. Capable of producing oil-free air at around 100 p.s.i., the compressors are said to have been successfully tested in sizes ranging from 7·5-60 cu.ft./min., a larger version of 1,000 cu.ft./min. being at present undergoing trials. A modified form of the same working principle is also offered as a pump for liquids.

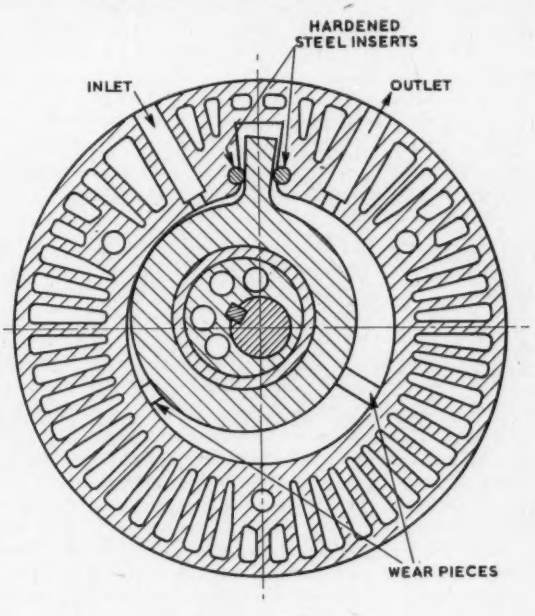
Although a number of pumps, having a rotary displacement piston much as in the sectional drawing, and operating on somewhat similar lines, can be found in textbooks, in these the vane is usually made to slide in a pivoting element and is therefore parallel-sided. Sometimes the vane is fixed to the wall of the pump body and slides in a slot cut in the displacement piston. In the August air compressor the vane is not parallel but slightly curved, and makes line contact with two hardened steel inserts. In the larger versions the inserts, which project slightly from the sides of the recess cut in the body of the compressor, are free to rotate.

The compressor body and piston are made of light alloy. A very slight clearance between the piston and the body ensures that no wear takes place on the outside diameter of the piston and the inside bore of the compressor body. Wear pieces of anti-friction material, however, are provided in the back wall of the body. These take the form of slightly projecting inserts.

Perhaps the most notable feature of the compressor is the inherent ease of manufacture when compared with a piston or vane compressor. The small version shown in the photograph is powered by a ¾ h.p. motor, and provides 7·5 cu.ft./min.

The inventor claims that his compressor can be manufactured for approximately one fifth the cost of a piston compressor of comparable output. Manufacturers interested are asked to contact Dixon DuPont Ltd., Cross Keys House, 56 Moorgate, London, E.C.2.

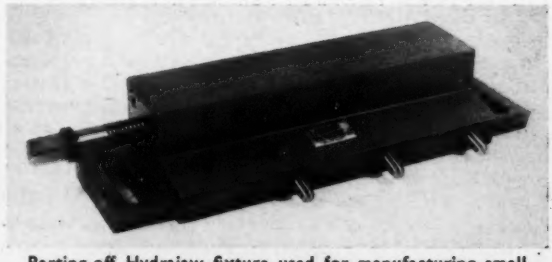




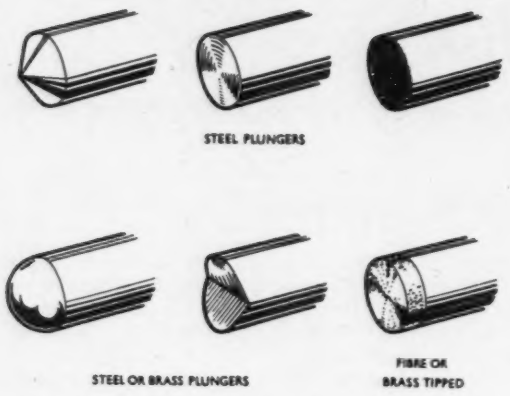
New Work-clamping Devices

WITH the introduction of a range of hydraulic vice jaws and clamping fixtures designed and manufactured by Larrad (Hydrajaws) Ltd., and distributed in England and Wales by Alfred Herbert Ltd., many of the limitations imposed by normal vices and clamps are said to be eliminated.

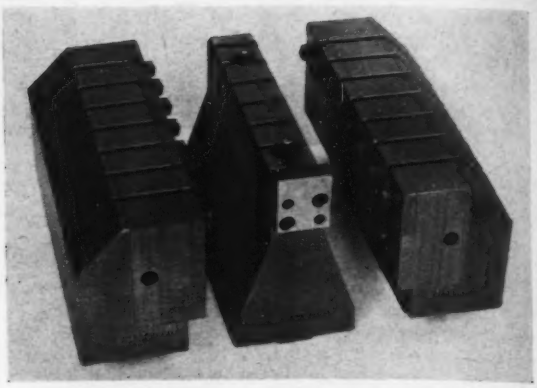
The Hydrajaws are simply constructed, and employ the well-known principle of uniform distribution of an applied pressure throughout a liquid. In essence, they consist of mild-steel blocks suitable for inserting in the machine vice, and are provided with a series of protruding plungers with which the workpiece is gripped. The spaces behind the plungers are filled with hydraulic oil, and are interconnected, thereby enabling the plungers to adjust themselves



Parting-off Hydrajaw fixture used for manufacturing small brackets from angle-iron. Two lengths of angle-iron are clamped together in the fixture, each piece being securely held throughout the operation.



Range of plunger heads that can be supplied fitted to the standard Hydrajaw units.



Standard Planer Hydrajaw with three spiking-down plungers angled at 15°. Both right- and left-hand versions are available from stock. A reversible ratchet spanner is also supplied.

automatically to the contour of the workpiece as the vice is being closed, and also to exert equal pressures when the vice is fully tightened. In practice it has been found that, in addition to applying equal pressures, the clamping effort of each plunger when the vice is only moderately tightened is greatly in excess of that applied by the vice alone.

Operating on the same principle is the Hydrajaw Clamp, which resembles in appearance the conventional solid jig-and-fixture clamp. The advantage of this clamp is that in place of the normal solid clamping pads there is a row of clamping plungers, again interconnected by hydraulic oil giving fully compensated clamping. The use of spherical seatings and washers is said to be unnecessary.

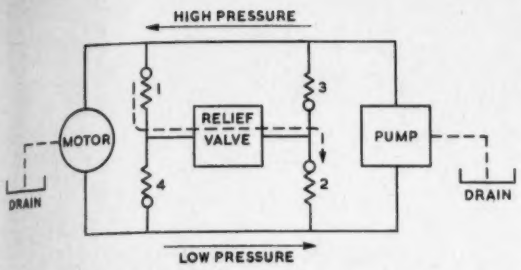
A logical development of the vice jaws and clamps described above is the design of a series of Hydrajaw Fixtures. In these the pressure is applied to the fluid by means of a screwed master plunger embodied in the unit, otherwise the principle is the same, namely that of a hydraulically-compensated closed-circuit multi-point clamping unit. The advantages are that irregularly shaped components or a number of small components can now be held by one Hydrajaw Clamp actuated by turning a single screw. Conventional methods of holding these components, with a series of small clamps each having a separate clamping screw, can now be eliminated, and considerable reductions in floor-to-floor times are claimed to be possible.

Hydraulic Drive for Extruder

BLOW-MOULDING machines and plastics-extrusion machines usually consist of a hopper, a compression and heating chamber, and an exit nozzle. The drive for extruding the plasticized material is provided by an expensive scroll in the compression and heating chamber which, on slow rotation, forces the material through the restricted nozzle. The design of the feed-scroll necessitates precise torque limitation and a safety factor to prevent the screw from being driven while the plastics material is in its solid or semi-solid state. Attempted driving of the feed-scroll while the plastics is solid can result in irreparable damage to the scroll and a consequent heavy replacement cost. An interesting application of a hydraulic drive which provides for the low speeds required, and gives full protection for the feed-scroll, is shown in the accompanying photograph.

Chamberlain Industries Ltd., in co-operation with the Amigo Machine Co., have fitted a Staffa hydraulic motor to the Blow-Master extrusion machine. The hydraulic motor used is a five-cylinder type, which has a nickel-chrome crankshaft, with a tensile strength of 55 t.s.i., and automotive-type pistons. The performance of the hydraulic motor is improved by running-in, but no life forecast is possible since at the time of writing none of these units has worn out in service, although many are credited with over 5,000 hours use.

The hydraulic motor shaft is connected directly to the feed-scroll, and the motor is fed by a pump of the variable-delivery type to give speed variation. A "closed-circuit" is used in which the outlet of the pump is connected to the inlet of the motor and the outlet of the motor to the inlet of the pump.



To safeguard against over-driving the feed-scroll, a pressure relief valve is incorporated in the circuit. By the use of four check-valves only one pressure relief valve need be used, thus reducing costs (see diagram). To avoid emptying the circuit when the relief valve lifts, the oil must pass from the high- to the low-pressure line.

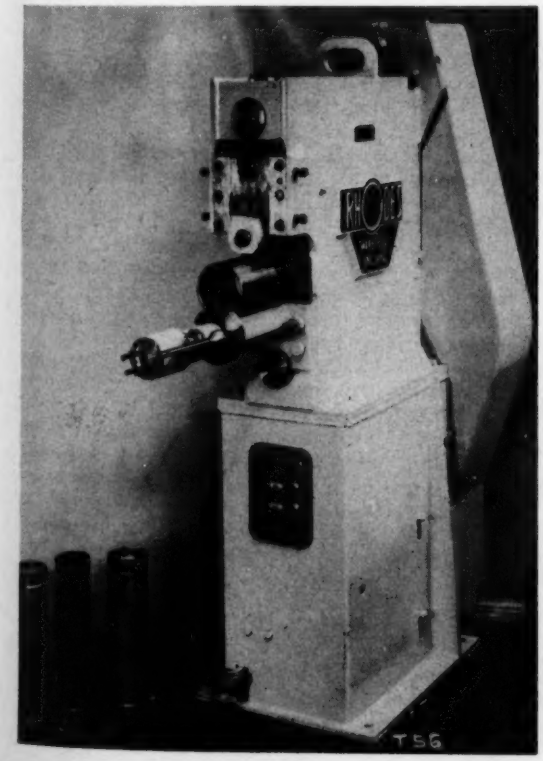
In the event of there being any restriction on the rotation of the feed-scroll, the high-pressure oil will pass through one of the check valves *1*, through the pressure relief valve, and will seek to pass through the second check valve *2* which leads to the low-pressure line. The check valve *3*, which leads to the high-pressure line will be clamped against against its seat by the high oil pressure. The additional check valve *4* enables the same process to take place if the direction of rotation is reversed. For simplicity, the boost-pump, filters, etc., have been omitted.

Special-purpose Machine for Producing Internal Beading

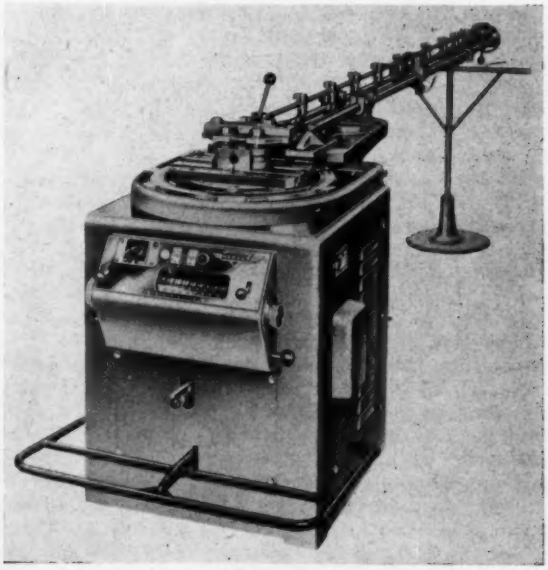
TO meet the special requirements of a manufacturer who needed to produce an internal stiffening bead at approximately 1 in. from the end of a cylindrical lamp chimney. Joseph Rhodes & Sons Ltd. recently designed a special beading machine.

The workpiece (seen in the photograph) is placed on a mandrel and held by a quick-operating clamp. The beading rolls run continuously; depression of the treadle engages a clutch operating a cam motion which lowers the top rotating roller onto the workpiece. The necessary pressure is applied in four stages. At the end of the cycle, the roller returns to its starting position, and the workpiece is removed, leaving the machine ready for the repeat operation.

Machines of this type could readily be adapted to carry out beading operations on cylindrical objects of a similar nature, and the manufacturer is prepared to offer designs suited to the requirements of any user.



High-speed Tube Bender with Programme Control



A NEW automatic production tube-bending machine, the Staffa-Herber SBA 28, claimed to be capable of producing 500-600 bends per hour, has been introduced by Chamberlain Industries Ltd., manufacturers of the Staffa range of pipe benders. Among the many new features of this machine is a patented device which permits right- and left-hand bends to be made without resetting the machine and tooling. This is possible even when successive bends are directly adjacent to each other without an intervening straight section. In certain cases bends of different radii can be produced without the necessity of changing centre formers.

A pre-selector on the control panel permits up to twelve bending variations without resetting any levers, and is automatically controlled after each completed bending operation. The bending head returns automatically, and the workpiece is ejected from the centre former groove.

The Staffa-Herber SBA 28 is a mandrel-type machine, and has a pipe length stop assembly with ten adjustable stops. The stops are lifted centrally as the tube is loaded over the mandrel. The drive unit, a worm gear running in an oil bath, is operated by a steel disc clutch, this system having proved to be very efficient.

GRAVITY DIECASTING IN ALUMINIUM BRONZE

The author describes, stage by stage, the production of aluminium bronze diecastings in a foundry specialising in this class of work, and also indicates the types of component which may be produced.

by R. W. FIRTH, B.Sc.(Hons.)*

AMONG the copper based non-ferrous alloys employed in the engineering industry, aluminium bronze is probably one of the most outstanding in regard to its general properties, and possibly, the most neglected in its application. Other copper alloys are often employed where aluminium bronze could show a saving in weight and a considerable advantage in mechanical and physical properties.

Reference to Table 1, which gives the British Standard Specifications for the two aluminium bronze alloys in most common use, will indicate the exceptionally good mechanical properties which characterize these alloys. The Air Ministry Specifications DTD 174A and DTD 412 are similar in most respects to BS 1400 AB1 and AB2 respectively. Under the majority of conditions the corrosion resistance of aluminium bronze is superior to that of many other copper based alloys in general use, and its high resistance to fatigue loading is also worthy of consideration.

Gravity diecasting represents in a large number of instances the most economical way of producing a given component, as it enables a high degree of accuracy to be obtained in the cast state. A cast tolerance of $\pm 0{\cdot}010$ in. is normal, and even closer control is possible if required on certain dimensions; this enables machining and other finishing operations to be reduced to a minimum. The mechanical properties obtained by the gravity diecasting process are much higher than the specified minima, 40 t.s.i. being usual for AB1 with an elongation of over 30 per cent.

The main limiting factor governing the suitability of a design for diecasting is whether it is possible to form the shape required by means of permanent die parts which can be removed and reassembled each time a casting is made. If this is not the case, it may be necessary to use a sand core for some part of the component. This, of course, slows down the process and increases the cost, and can often be avoided by some redesigning of the part. The minimum section thickness is normally 3/32 in., although small areas can be cast slightly less than this.

*Director and technical superintendent, Sagar-Richards Ltd.

Die Design

On receiving from a customer the drawing of a component to be produced, it is examined and the most satisfactory method of casting evolved by the die design staff. In some cases slight modifications may be necessary to the design of the component in order to suit it to the method of production, and these must be acceptable to the customer. At this point it may be emphasized that collaboration in the design stages of the component between the customer's designers and the technical staff of the diecasting foundry can be extremely useful, and may often obviate delays at a later stage.

Once the customer has accepted the design of the component as it is proposed to supply it, the actual detailed design of the die may begin.

The simplest type of gravity diecasting die consists of two half-moulds or "die-sides" into which the form of the casting is cut together with a suitable runner system to feed the molten metal into the casting. A die of this type is shown in Fig. 1. It will be obvious that the shape of the casting must be such that it will readily leave the two halves of the die when these are separated.

In order to produce undercuts, recesses, or holes in the casting, loose pieces must be employed in the die—these are known as cores. A more complex die incorporating a number of cores is shown in Fig. 2, together with a casting produced from it. It will also be seen from this photograph that the joint between the two "die-sides" is not straight, but follows the centre line of part of the casting so that its release from the die is simplified. In most cases a two piece die with appropriate cores will produce the required component satisfactorily, but occasionally a die of three or even more pieces may be necessary.

The casting is arranged in the die as far as practicable so that directional solidification proceeds towards the runner, which should enter the heaviest section of the casting. Where this is not altogether possible, risers must be employed to feed any heavy sections remote from the runner. It is usual to arrange for the runner to enter the casting near its lowest point in the die in order that the molten metal may rise up the die, thus ensuring a clean

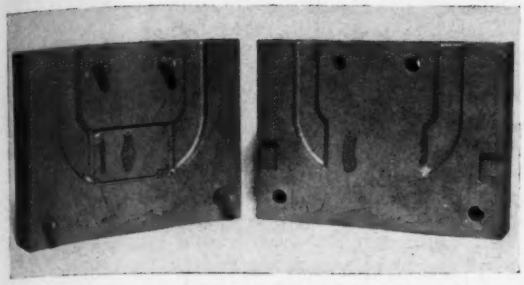


Fig. 1. Gravity die of simplest construction.

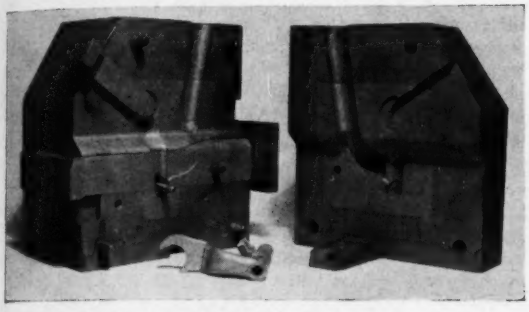


Fig. 2. Die of more complex design.

casting free from oxide films, which should remain in the runner. This is particularly important in the case of aluminium bronze, which forms an oxide skin very rapidly in the molten state. The runner, which is normally of circular cross section, and the risers, if present, must be sufficiently large to remain molten longer than the casting, so that any feeding requirements may be supplied. It is also necessary to ensure that the die is adequately "vented" by means of "air lines". The latter are fine grooves, cut across the faces of the die from the casting cavity to the outside of the die, which enable the air to leave the cavity as the metal enters, thus obviating trapped air pockets in the casting. Where a die contains a number of removable cores, the joints between the various parts of the die often afford adequate venting and air lines may not be necessary, although they are not of course detrimental.

As in all other forms of casting, a contraction allowance must be made in the design of the die; in the case of aluminium bronze this may vary from 0·012 to 0·020 in. per in. dependent upon the casting sections involved.

Dies for short production runs are normally made in a suitable grade of heat resisting cast iron, but, in the majority of cases, cast iron die sides are used with inserted blocks of heat resisting material, usually a Nimonic alloy carrying the actual casting shape. The small cores and the ends of larger cores are produced from similar material. The die shown in Fig. 2 is constructed in this manner. The reason for this is that the simple cast iron die when used for aluminium bronze diecasting has a short life, which can be measured in hundreds of castings, but a die in which a Nimonic alloy is used for the casting surfaces may produce up to 100,000 castings before requiring renewal. Small cores, even in heat resisting material require more frequent replacement, due to the higher temperatures which they reach in service.

Die Manufacture

Little need be said about die manufacture as, although requiring great care and accuracy, production follows normal tool room practice. The Nimonic material is not easy to machine, but presents no insuperable difficulties if the correct technique is adopted.

After the cast iron blocks have been cleaned up to size, pockets are milled in them to receive the inserts of heat resisting material, which are held in position by screws from the back of the die side. The "form" of the casting and any core recesses are then milled and/or turned in to the composite die sides, which are located by dowels and a guide bar or can be seen in Fig. 2. The cores are prepared with mild steel heads and heat resisting ends, and are fitted to the die. Prising slots are milled into the ends of the die sides to assist in opening it after a casting has been poured. When the die is complete, a wax impression is cast in it to check on general die accuracy and matching. The die is then ready for sampling in the foundry.

Production of Castings

The production of castings of finished weight ranging from a fraction of an ounce to upwards of 40 lb., and having wide variations of shape and complexity, calls for great flexibility in manufacture. No two dies for castings of different type can be worked in exactly the same manner to obtain the best results, and in the present article it is impossible to describe the casting process in more than general terms, based on the practice followed in the works with which the author is associated.

The metal required for casting is made up from virgin copper, aluminium and a copper-aluminium-iron hardener, as the latter has been found the most convenient way of introducing iron to the melt. In the case of the AB2 alloy, copper-nickel shot is also added. Alternatively, commercial aluminium bronze ingots of high quality may be used for either alloy. A proportion of returned scrap from the machine shop, i.e. runners and risers removed from previous castings, must also be used. A constant check of the resultant metal is maintained, and, in the foundry itself, hardness tests are carried out on each batch of metal before it is used for casting.

The metal is melted in electric furnaces of the mains frequency induction type. These are Birlec-Tama furnaces of single chamber design, but the bath is divided by a central tile to prevent solid material which is charged at the back entering the front portion of the furnace, from which metal is baled out for casting. The furnace is thermostatically controlled from a pyrometer in the charging side, and it has been found that by controlled charging it is possible to charge and bale out simultaneously, while maintaining furnace temperature within ± 10 deg. C. of the required casting temperature. This is quite satisfactory, and is much better than can be achieved by most other types of melting. The electric furnaces have the additional advantages of being far more economical to run than oil- or gas-fired furnaces, and result in a lower melting loss and a much cleaner foundry atmosphere. Each furnace is fitted with an exhaust system of the low-volume, high-velocity type, to remove any fumes which are produced—these arise mainly from the flux used for breaking up the dross which forms on the surface of the bath.

Each furnace is capable of a through-put of 500-600 lb. of aluminium bronze per hr., and is worked by a furnaceman who is responsible for charging it, maintaining correct metal temperature, and looking after the furnace generally. Two groups of four men work at each furnace, each group consisting of one pourer and three casters. The pourer removes metal from the furnace with a heat-resisting steel hand-ladle, and carries it to the group of three casters, each working an individual die on benches placed a few feet away from the furnace. He then fills the dies in turn with metal from the ladle, taking care that no dross which may be in the ladle enters the die. The pouring of metal into the die is not as simple a process as it may appear, as different dies require slight differences in pouring tech-

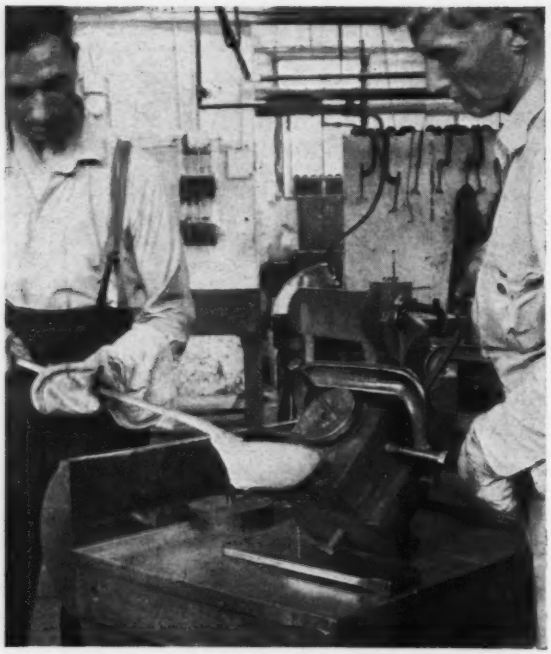


Fig. 3. Die about to be filled with metal.

nique, which though difficult to describe on paper, have a very real effect in practice. This type of skill can only be acquired by experience. Aluminium bronze is subject to rapid oxidation, and the metal in the furnace must be fluxed and skimmed regularly by the pourer, to prevent an accumulation of dross forming which could be the cause of inclusions in the castings. Fig. 3 shows a die being poured.

The caster requires possibly less skill than the pourer, as the method of working the die can be fairly rigidly laid down. The die sides are held together by one or more G clamps of rigid construction during the pouring of the casting. It is usual to tilt the die prior to pouring, and to return it slowly to its position on the bench as the metal enters. This practice, which is of the same principle as the Durville process, helps to ensure that the casting has a clean surface, as any oxide film which leaves the ladle remains in the runner and does not enter the casting, and the casting itself fills without turbulence, thus avoiding any cold shuts due to further oxidation. Except in the case of large castings, the solidification is so rapid that the caster may commence to dismantle the die immediately after pouring is complete. The cores are withdrawn by means of prisers in a definite order to minimise distortion of the casting, the clamps are removed, and the die sides prised apart so that the casting and runner system can be taken out. The casting is still bright red hot at this stage, but the strength of aluminium bronze at high temperature is such that there is negligible risk of distortion if the casting is handled carefully. After ensuring that the component parts of the die are clean and free from any small pieces of metal or "flash" which may have been broken from the casting, the die is reassembled for pouring again. In the case of dies for large parts, two casters may be required due to the weight of the die components involved.

It has been found that this simple method is the most rapid and flexible, and no improvement has been considered possible by the use of mechanical aids such as hydraulic die-opening or core-pulling mechanisms.

A small die maintenance department attached to the foundry ensures that the dies are kept in the best possible condition by examining them after each period of use, and returning them to the tool room if any major repairs are necessary. Only dies in use are allowed in the foundry; all other dies are held in racks in a heated die store to prevent corrosion. Complete records are maintained of the history and performance of each die, and these provide valuable information when a new die is to be designed for a similar part. The correct method of working each die is also recorded.

Finishing of Castings

After removal from the foundry, the castings, complete with runners, etc., are given a preliminary inspection which is of a visual nature aided by a number of simple gauges. The castings are then transferred to the first section of the machine shop, where the runners and risers are removed. The castings are held in suitable fixtures, and the runner and risers (if any) removed by slitting saws on cutting off machines. The metal removed is returned to the foundry for remelting.

The castings are then taken to the second section of the machine shop, where the remaining unwanted metal, such as the runner and riser stubs and the "flashes" caused by metal penetrating the joints between die components, are removed by disc or tape grind, chipping and filing.

A certain number of castings, either not requiring machining or to be machined by the customer, are finished at this stage and proceed directly to the final inspection and despatch department.

The remainder, which require machining to customers' requirements, are catered for by a wide variety of machine

Figs. 4 and 5. Typical examples of aluminium bronze diecastings.

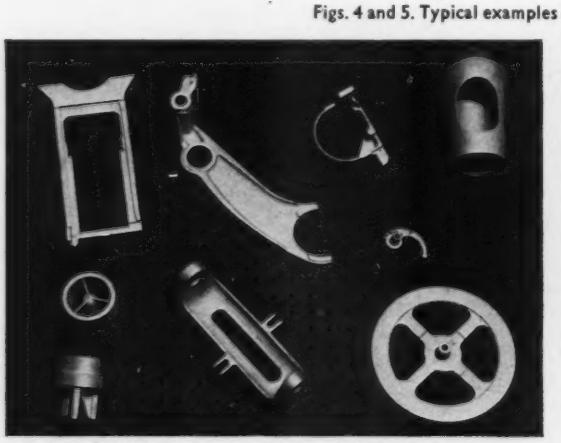


Table 1. British Standard Specifications for two aluminium bronze alloys in common use

British Standard 1400 (Specifications)	Composition							Mechanical Properties	
	Cu (%)	Al (%)	Mn (% max.)	Ni (%)	Fe (%)	Zn (% max.)	Other impurities (% max.)	Tensile strength (t.s.i.)	Min. elongation in 4/A (%)
AB1–C Castings	Rem.	8.5–10.5	1.0	1.0 max.	1.5–3.5	0.50	0.30	32	20
AB2–C High tensile castings	Rem.	8.5–10.5	3.0	3.0–5.5	3.0–5.5	0.50	0.30	40	12

tools capable of carrying out practically any operation which may be called for. A number of automatic machines allow high speed machining of components which are called for regularly in large quantities, such as automobile parts. The machining of aluminium bronze requires a somewhat different technique from that used on the lower strength copper alloys, but once this has been established, and a certain amount of experience accumulated, results can be obtained which are in no way inferior to those with almost any other engineering material.

Inspection and Quality Control

As previously mentioned, all castings from the foundry undergo a preliminary visual inspection with the aid of simple gauges. Before despatch, all finished castings are subjected to a rigorous final inspection in which, by use of special sets of fixtures and gauges for each part, they can be carefully checked to the customers' finished sizes.

In addition to the routine inspection procedure, a careful control of quality is maintained by the metallurgical department on all incoming materials, and on the melting of metal for the production of castings. The first batch of castings from every new die is, in addition to being checked dimensionally, subjected to a 100 per cent radiographic examination to discover any unsoundness. Any necessary alterations are made to the die, and a further batch of castings radiographed, until satisfactory castings are obtained. A casting is then submitted to the customer for dimensional approval, and when this is received, the die is passed for production. The X-ray set is of the 200-kV. type, and is capable of penetrating any casting in current production. It is also used in the investigation of complaints from customers regarding defective castings.

Any castings which may be susceptible to cracking are examined by a fluorescent crack detection unit, which reveals cracks invisible to the naked eye. Certain castings are ordered subject to the inspection procedure of various authorities such as A.I.D., and are dealt with accordingly.

In addition to regular quality control, the technical staff is constantly experimenting with new materials to improve die life, and new methods to improve casting quality and to increase still further the economic efficiency of the process.

Conclusion

An attempt has been made in this article to show that aluminium bronze gravity diecasting is one of the most economic methods of producing medium or large quantities of a given component in a high strength engineering material, with excellent corrosion resistance in most applications. It is not normally worth making a die for an initial order of less than 500 castings.

The company with which the author is associated produces an extremely wide range of parts (see Figs. 4 and 5), which are used in practically every branch of the engineering industry. At present the automobile manufacturers are by far the largest users of aluminium bronze diecastings, but it is certain that there are still numerous applications in which aluminium bronze diecastings could be substituted with superior results and reduction of costs.

The author wishes to express his thanks to the directors of Sagar-Richards Ltd. for permission to publish this article.

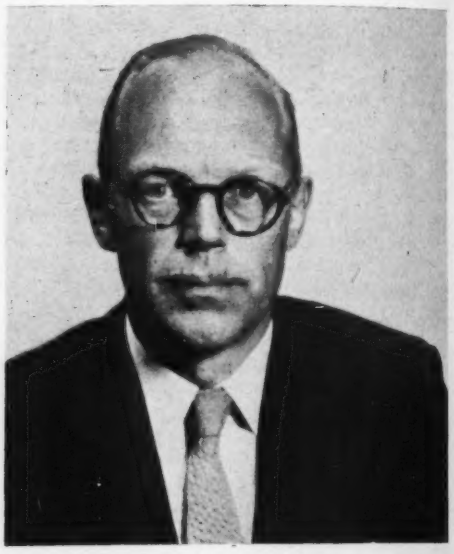
COSTS OF BASIC MATERIALS

THE following prices are given as a rough guide to designers who wish to know the approximate cost of a basic material. In the case of plastics the figures given refer to moulding material, but these prices may be higher if special fillers, dyes or pigments are incorporated. The price for plastics varies also according to quantity.

Metal	Density	Price
Steel (wrought):		
Heavy steel angles (per ton) ..	7.8	£38
Bright bar (per ton)	7.8	£53
Aluminium casting alloys:		
BS 1490 LM4 (d/d per ton) ..	2.7	£170–£174
BS 1490 (LM6 (d/d per ton) ..	2.7	£176–£180
Lead in warehouse (per ton) ..	11.4	£64
Nickel delivered (per ton) ..	8.9	£600
Magnesium casting alloy (per lb.) ..	1.74	1s. 11½d.–2s. 1d.
Silver (per troy ounce)	10.5	79¼d.
Rhodium (per troy ounce) ..	12.4	£43–£50
Molybdenum powder (per lb.) ..	10.3	30s.–35s.
Platinum (U.K. and Empire) (per troy ounce)	21.5	£30½
Titanium sheet (per lb.)	4.5	73s.
Stainless steel billets (austenitic per ton)	7.8	£219½
Aluminium ingot (per ton delivered)	2.7	£186

Material	Density	Price
Zinc diecasting alloys:		
BS 1004 A ingots (per ton) ..	6.7	£113 6s. 3d.
BS 1004 B ingots (per ton) ..	6.7	£117 6s. 3d.
Brass 65/35 ingots (per ton) ..	8.5	£182
Phosphor bronze strip (per ton)	8.8	£400¾
Solder sticks, ½ to 1 ton lots, ex works (per ton)	—	£440
Tin in warehouse (per ton) ..	7.3	£880
Gold (per troy ounce)	19.3	251s. 4d.
Ferro-chrome, 0.06% C (per lb. Cr.)	—	1s. 11d.–2s. 1d.
Tungsten ore (per unit WO_3 c.i.f.)	19.3	125s.–129s.
Palladium (per troy ounce) ..	11.9	£8½–£9⅜
Copper wirebars in warehouse (per ton)	8.9	£239½
Plastics	**Density**	**Price (per lb.)**
P.t.f.e.:		
powder	2.2	£2–£2.10s.
granules	2.2	£1 7s.–£1 14s.
P.v.c.	1.3–1.6	1s. 6d.–2s.
Polythene	0.92	1s. 10d.–2s. 6d.
Polypropylene	0.91	3s.–3s. 6d.
Acrylic	1.2	3s.–3s. 6d.
Nylon	1.1	7s. 6d.–8s. 6d.
Polystyrene	1.05	1s. 6d.–2s. 6d.

WHAT NEW MATERIALS DO YOU REQUIRE?



B. G. ILLINGWORTH, assistant director of engineering, English Electric Co. Ltd.

ONE of the main difficulties in the medium and heavy electrical engineering fields lies in producing the equipment at an economic price. New materials are generally required capable of meeting higher stresses and higher temperatures. They must be corrosion resistant and in many cases have improved electrical and magnetic properties. However, such materials tend to be expensive, and many of them can only be used if they result in economies in other directions.

A typical example is the use of silicones in the insulation of electrical machines. These allow the machines to be run at higher temperatures, thus increasing output from a given size. In certain applications where size and weight are important, railway traction for example, the increased cost can already be justified.

Running electrical machines at higher temperatures usually results in a drop in efficiency. It would thus be most useful if one could use a material with better electrical conductivity than copper or, alternatively, one with a lower increase of resistance with temperature. Such materials do of course already exist, but their cost precludes their use for this purpose.

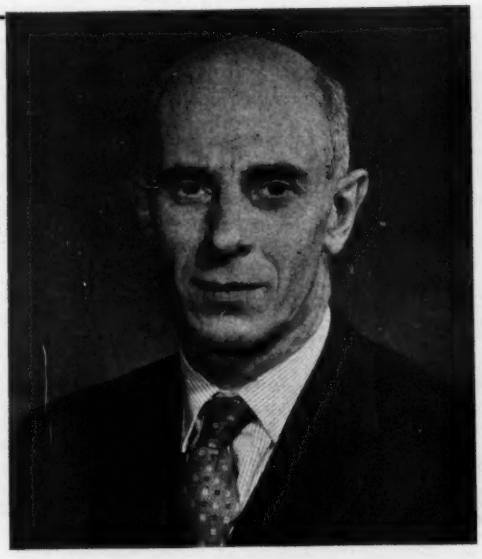
One field where improved materials would be most valuable is the production of endbells for turbo alternator motors. These are used to contain the end windings, and at present seriously limit the size of alternator which can be built. A difficulty with existing steels is that with increasing rotor diameter more and more of the strength of the endbell is used up just holding itself together, and little is left to withstand the centrifugal force exerted by the windings. The requirement here is thus for a lighter material with high tensile strength and completely uniform properties.

The permeability of electrical sheet steel has not advanced significantly. The cold rolling process has improved this, in the direction of rolling, and latest techniques produce better performance in two directions. If, however, some equally cheap material with much improved flux-carrying capacity could be found then this would be a major break-through.

Gas turbine requirements have resulted in the development of materials capable of withstanding both high stress and high temperature. Such materials could be used in the early stages of steam turbines in spite of their high cost. However, the economic problems of suitable materials for the superheater and pipework are very real, mainly on account of the much larger quantities involved.

It will thus be seen that in the majority of cases it is not only a question of the availability or otherwise of technically suitable materials—the price also must be acceptable.

Designers are still restricted in many engineering developments by lack of suitable materials. Here, two prominent personalities in engineering explain the needs of their particular branches of industry



S. H. FREDERICK, chief metallurgist, Parsons & Marine Engineering Turbine Research and Development Association.

IN many branches of engineering the suitability of a material for a specific component is based on its physical and mechanical properties at atmospheric temperatures. Turbines on the other hand, whether steam or gas, operate at elevated temperatures, the level of which is dependent on the high-temperature properties of the materials available to the designer, and the service life that he requires.

For a given material the maximum service temperature is a function of the stress and life required without the strain due to creep exceeding a stated value. It follows therefore that for such applications as aircraft turbines, where the life is measured in hundred of hours, it is possible to use levels of temperature and stress that would result in failure were they used in turbines designed for land or marine applications, where the expected life is measured in tens of thousands of hours.

In the case of marine turbines the service conditions demand reliability, economic operation and long life. Increased thermal efficiency results from the use of high inlet temperatures, and since 1945 steam temperatures have risen from 400 to 510 deg. C.—prototype machinery with a maximum steam temperature of 565 deg. C. is under construction. The continual strive for economy must not however be undertaken at the expense of reliability, which must be placed above all other considerations as failure of main propulsion machinery at sea not only entails heavy financial loss but can endanger human life.

This emphasis on reliability has a profound influence on the marine turbine designer's attitude to new materials. He cannot afford to incorporate any material until its behaviour at elevated temperatures for times upwards of 10,000 hours has been established, and known to be obtainable in the size of component in which he is interested. Many materials which, as far as the marine turbine designer is concerned, may be termed "new", are well established in relation to aircraft turbines, but available data on their high-temperature properties is limited to a few thousand hours.

It is therefore not strictly true to say that development of marine turbines is restricted due to lack of suitable materials. What is at present required is more "long time" data on the existing advanced materials, although even if this were available many of them are too expensive to warrant their use. With regard to requirements from existing low alloy materials, more progress could be made if their properties could be more accurately forecast, so that safety factors which allow for scatter of results could be eliminated. Another example is the production and inspection of rotor forgings. If these could be supplied with confidence without the need for boring, some of the stress problems would be greatly simplified.

What the turbine designer really wants is a material as light as aluminium but as strong as steel, having the thermal conductivity of copper and thermal expansion characteristics of Invar, together with the mechanical properties of the best high-temperature materials available today. His dream may never come true, but each year some progress is usually made in one direction or another.

LETTERS TO THE EDITOR

Insulation of Windings

Sir,

I am sorry that Mr. P. Howard considers that my article "Insulation of Windings for Traction Machines: Part 3", published in the April 1961 issue, is misleading. To the best of my knowledge, the majority of machines manufactured in this country to meet Class H requirements do not incorporate electric windings that are entirely built with this class of insulation. They normally use a combination of Class F and Class H materials which allows machines to operate at the temperature assigned to Class H, that is, 180 deg.C.

Although they have been experimenting for approximately ten years, the London Transport Executive have still to satisfy themselves that Class H traction motors will have a longer life than the Class B machines, many hundreds of which were manufactured as long ago as 1937. These machines are still operating satisfactorily. The reason that photographs of American-built machines were included is that I have not been able to find photographs of any British machines in which both field and armature systems use entirely Class H materials.

It may interest Mr. Howard to know that I am at present writing a book on the insulation of traction machines, and that I am deleting a recommendation for the use of Megasil 1400 and also the use of silicone greases in the treatment of tape for storage purposes.

W. Duckett

Walsingham, Oaklands Crescent,
Chelmsford, Essex.

Can You Beat a Sackbut?

Sir,

I have a peculiar problem in connection with some practical research on old musical instruments, and wonder if you could possibly help in any way.

Two families of instruments were very widely used in "pops" and "classics" of every sort from the fifteenth to the eighteenth centuries—cornets and sackbuts. I am especially interested because the proper performance of much great music is impossible without them. I can make cornets satisfactorily, but sackbuts—close relations of the trombone—are rare (only five in this country that I can trace), and need the skill of metalbeating to make. I have the use of four of the surviving originals here but it is difficult to be certain, because of leaking slides for instance, that the special sound they produce now is entirely in the design. The modern trombone is built especially to produce a ringing magnificent trumpet-like tone: the sackbut was certainly used in a very different way, in gentler vocal style. It is extremely difficult for a modern player to accompany recorders, for instance, on a trombone. A sackbut was often called on to do so. There is no doubt about this. What is in doubt is whether the sackbut had essential differences which enabled a player then to do easily what a player now finds exceedingly hard. I have good reason to think it had.

The simplest way to establish the point is to make sackbuts that are mechanically efficient and play them. I have an unique group of cornets and sackbuts, and one of the leading instrument manufacturers was interested enough in our activities to make and generously present a reproduction of the best original we could produce. This has partly established that my contention is right, but not entirely, because although the dimensions are right the metal is of a modern variety not used in sackbut times, and the bell was made by hydraulic extrusion as is a common modern practice. The old method was to use a brass sheet of apparently softer quality, and to beat it to a required shape.

Can you possibly put me in touch with an apprentice or craftsman who could, for a reasonable price, beat out two sackbut bells, one big, one small, to as close as possible an imitation of the originals we have? The big makers of instruments no longer seem to have craftsmen of this sort, though the ones who were so generous to us undoubtedly have craftsmen of a very high order still. There is little money forthcoming for any musical research of any sort in this country, and in this case it is sadly convenient to make do with modern instruments that look similar, even if they sound so loud and splendid that they overwhelm everything else as a rule. On the other hand the problem is regularly discussed whenever performances of much wonderful early music is planned—and seldom if ever satisfactorily solved, here or elsewhere on the Continent or in America. I feel that it should be possible to settle such a small but insignificant point somehow, without waiting for the German craftsmen to get round to it, as I suppose they will one day.

C. W. Monk

St. Edmund's, Hindhead, Surrey.

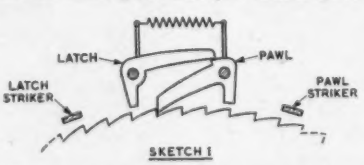
Problem in Design No. 16

Sir,

The solutions to Design Problem No. 16 [set in the February issue, answered in June] were awaited with interest, and it is not surprising that entries were scarce. The problem was not realistic . . . "one would not do it that way".

A possible solution would be as follows:

Two identical "latched pawls" are fitted to the lever and frame respectively, co-acting with suitable teeth on one of the drum cheeks. The frame carries retractable strikers operating on the lever pawl unit, and the lever has similar strikers operating on the frame pawl unit (see sketch 1). A



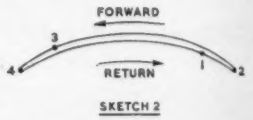
SKETCH 1

single-acting spring-return cylinder with orthodox valve gear operated from the lever is used to give simple oscillation to the lever.

With the strikers retracted, turning on the air raises the load in the obvious manner.

Since the load is not *driven* downwards, the ratchet is not reversible in the true sense: it is a permissive release against air pressure caused by a suitable restriction valve, a "hand-over-hand" action.

Call the lever pawl *A* and the frame pawl *B*. The lowering sequence when the striker gear is operative is as follows (see sketch



SKETCH 2

2): Position 1, *B* engaged . . . load arrested; Position 2, *A* disengaged . . . forward stroke idle to Position 3; Position 3, *A* engaged . . . load raised slightly; Position 4, *B* disengaged . . . load lowered to Position 1 while exhausting against restriction valve. Cycle repeats.

Should the air be cut off or fail, the system will always return to Position 1—i.e. the system fails safe.

Using a self-centring two-way control valve with the lever mechanically coupled to the striker gear, the circuitry can readily be arranged to give "lift" for lever up and "lower" for lever down.

If a lighter note is permitted, the most elegant solution would be a new works' engineer!

W. Brown

873 Chester Road, Birmingham, 24.

Problem in Design No. 17

Sir,

I am very disappointed to note in your July issue that you appear to have missed the point in the design which I submitted. You state that "such an arrangement could not be considered satisfactory for a two-way drive, as in one direction of rotation the driving side would be operating against a spring . . ."

If you would re-read my explanatory note, you will see that I was careful to overcome this feature by the very simple means of changing the pointer from one side to the other when changing the direction of rotation. This ensures that the drive side of the chain is always positive, the spring loading being always on the slack side.

I appreciate that the use of helical gears provides a very nice solution but it is obviously extremely expensive by comparison with a simple chain and sprocket, which, after all, is common practice in the great majority of motor car engines. The only drawback, as I pointed out, was the possibility of chain stretch, which is the normal hazard with this type of mechanism.

C. D. Waters

"Robin Hill", The Straight Mile,
Ampfield, Romsey, Hants.

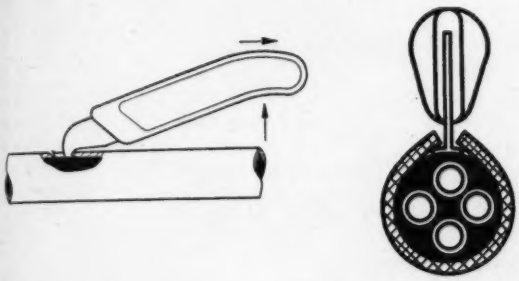
We would apologise to Mr. Waters for stating that his sprocket and chain device would not be suitable for a reversible engine. We would like to emphasise, however, that we are very conscious of our own fallibility in adjudicating this feature which must, in the nature of things, be a somewhat controversial one—EDITOR.

OVERSEAS NEWSLETTER

A monthly digest of reports from our foreign correspondents of other countries' current achievements in research and development work

Knife for Removing Insulation

A simple but effective way of removing the outside insulation of a non-metallic sheathed cable, without endangering the core insulation, is by the use of the Guro knife, produced by Paul Jordan Elektrotechnische Fabrik, of Berlin. At the front edge of the cutting blade there is a small circular cutter plate which has a ground edge, and which is set at such an angle to prevent it cutting deeply into the cable. In operation, the cutter plate may be inserted either from an end of the cable or along its length ; by pulling, and slightly raising the handle, the cutter slides beneath the plastic outer sheath, thus effectively exposing the inner core without the risk of damage.



Super-plasticity during Phase Transformation

A significant rise of plasticity in steels and other alloys during the period of phase transformation has been observed by many investigators, and sometimes used without clear understanding in the practice of heat-treatment. Scientists at the Moscow State University have devoted attention for several years to these phenomena, and have recently put forward methods for the heat-treatment of precision components by making use of the temporarily increased plasticity, to achieve exactly predictable corrections of shape with the help of empirically established constants of the material.

During a phase transformation, a temporary and reversible increase in plasticity takes place under many conditions, including that of the martensite transformation. In many cases the changes are substantial, and have been used for example in the heat-treatment of laminated motor-car springs. At the same time, these phenomena can be highly undesirable. For example, in a heat-resistant material the mechanical properties are usually tested at room temperature, and at the operating temperature. The assumption that, at intermediate temperatures, the properties will lie in between the extreme values is not warranted when phase transformations are possible.

Broadly, it follows that methods for dimensional control during heat-treatment should be applied throughout the treatment procedure. For a long time it was assumed that the straightening of steel components when quenching in a hot medium is possible only by virtue of the increased plasticity of super-cooled austenite, and that it must be carried out during the period when the austenite content in the grain structure is at its maximum, in other words so far as possible during the period when it is inert. It is now claimed that, in reality, the possibility of successful straightening is explained in this case by the appearance of "kinetic" (temporary, reversible) plasticity of the steel. The best results are achieved when the straightening is carried out in the course of the transformation, and not before it begins.

It is stated that when measures for the suppression of distortion are applied at the correct time to make use of the enhanced plasticity, the stresses required are of the order below 1,420 p.s.i.

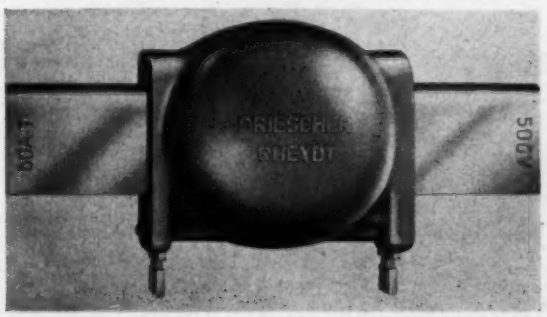
Tested results have been published of dimensional control in heat-treatment, including the achievement of a desired deflection in a rod. It is possible to use the simple relationships of the engineering theory of bending if empirical values are substituted for Young's modulus. In a typical case, Young's modulus in tempering at 480 deg. C. can be assumed as $3{\cdot}9\times10^6$ p.s.i. In austempering in a bath at 250 deg. C. the appropriate value is $2{\cdot}6\times10^6$ p.s.i. In normalising, the value 2.1×10^6 p.s.i. can be used. These values apply to low alloy steels.

Ceramic-coated Copper Wire

Cerafil, which was recently exhibited at the Twenty-fourth Salon International de L'Aéronautique, at Le Bourget, closely resembles ordinary varnish-insulated copper wire, both in appearance and in its complete flexibility. It is, however, a ceramic coated wire claimed to be suitable for operation continuously at temperatures up to 200 deg. C., and can be used for winding the coils of small electric motors and transformers. It is manufactured by the Compagnie Generale des Plastiques, 21 Rue des Moulins, Croissy-sur-Seine, S.-et-O.

H.r.c. Fuse for Low Tension

An interesting new cast resin fuse, Epomat 61, produced by Fritz Driescher, in Germany, has a high rupturing capacity. The epoxy resin connects the few component parts, effectively waterproofs them, and ensures that the fuse is practically unbreakable. The contacts are of copper, and the spot welded elements are surrounded by a large volume of sand. Owing to the high stability of the epoxy resin, high disconnecting capacities are obtained even with the most unfavourable phase angle at the moment of switching off.



New Acrylic Film

A new film-forming polymer, Carboset 511, is an acrylic polymer in a water solution that will dry at room temperature to form a clear, tough, glossy and water-insoluble film. Cast films adhere to metal, glass, cellulosic and proteinaceous surfaces, and resist boiling water. Prolonged immersion, however, causes whitening. Films of Carboset 511 may be applied with a brush or sponge. They are sensitive to alkalis, and may be removed by treatment with dilute alkali such as 2% ammonium hydroxide, or less readily by soap solutions.

Applications of two distinct types are suggested: (a) as temporary coatings that can be easily removed when desired, and (b) as coatings and binders that will not be subjected to aqueous alkali solutions. Other applications include its use as a floor polish additive, and for coatings on metals to provide acid resistance.

Carboset 511 is compatible with most other water-soluble dispersable systems and can be readily diluted with water for easy application. It is made by the B. F. Goodrich Chemical Co., and the agency in the U.K. is handled by Honeywill & Stein Ltd.

Extinguishing Powders

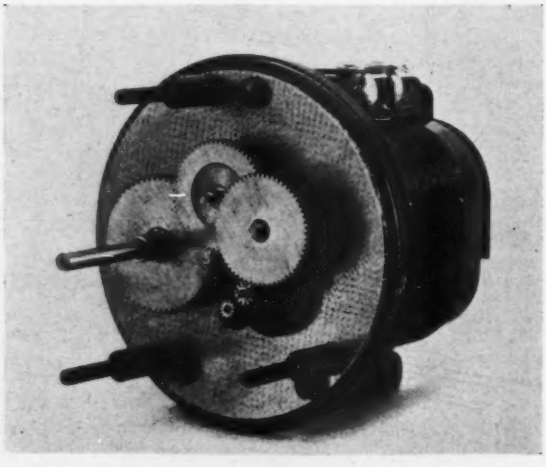
A recent patent assigned to Société Biro Fils defines a new composition which is suitable for extinguishing magnesium fires, since it does not disassociate when in contact with high-temperature flames. A typical composition is said to consist of a carrying agent containing wax or oil, excellent results being achieved by 10% pitch, 20% polythene and 70% urea in powder form.

Metallurgists at the U.K.A.E.A., at Dounreay, have produced and patented a not entirely dissimilar mixture of powdered inorganic chlorides and/or fluorides, inert to the pyrophoric metals for which they have been evolved.

In both the French and English extinguishing powders the melting point of the mixture is below that of the metal. Thus fusion of the powder takes place locally, where it is in contact with the burning metal and forms a skin which effectively prevents contact of the metal with the surrounding air. The U.K.A.E.A. suggests that, with their invention, absorption of latent heat by fusion of the powder exerts a cooling effect on the metal.

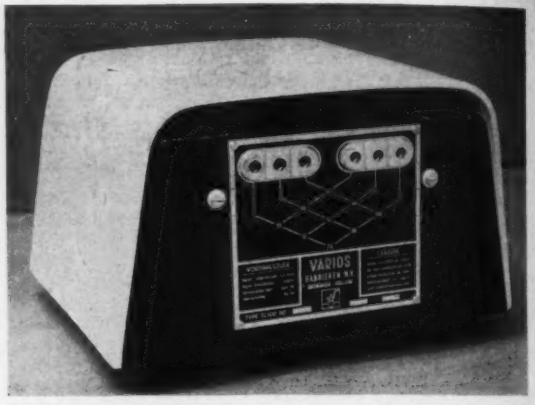
Miniature Motors

A range of hermetically-sealed synchronous miniature motors is now available (from LIP, of France) complete with gear heads. Type 943 will deliver a maximum torque of over 12 Kg.cm., while type 951 (see illustration) may be obtained with or without the gear head. A variety of speed reductions are possible, and these motors should find wide application as servo motors in various mechanisms. Type 951 has two standard voltage tappings of 127 or 220 at 50 c/s, the current consumption being 8 watts. Overall dimensions are 84 mm. dia. × 104 mm. long.



Welding Transformer

A new low-power welding transformer has been recently marketed by Varios-Fabrieken N.V., of Rotterdam. This unit is of light weight and compact dimensions, and draws a maximum of 15 amps at 220 volts, 50 c/s. It is ideally suited for the small garage and workshop, or for the do-it-yourself enthusiast. The open circuit voltage is 52 volts, and the welding current range 35 to 100 amps. The selection of the welding current is obtained in nine steps by means of contact plugs. Unlike most welding transformers, this one is housed in a modern, attractive yet functional case. An agency in the U.K. is being invited.



Liquid Mortar

P.C.I. Emulsion, produced by the Polychemie G.m.b.H., of West Germany, is a mortar additive for use with a cement-sand or cement-granular material. Used in the semi-liquid form it adheres permanently to old concrete, even in the thinnest layers, and requires no previous preparation. It is hardwearing, and ideal for repairs and new work.

New Epoxy Rubbers

A number of new epoxy rubber materials have recently been marketed by R.A.D. Electronics Plastics Inc., of the U.S.A. Their RAD Flex 1700 is a new vulcanisable epoxy elastomer which can be applied as a shock and moisture-proof vibration absorber between wire and cable spliced joints. It is available over a range of hardness values from Shore 15A to 70D without the use of plasticisers, and regardless of rigidity retains excellent electrical properties and abrasion resistance. During curing, the elastomer adheres tenaciously to almost all types of surfaces—where moulds are used, therefore, a release agent is essential.

RAD Epoxy Rubber 1800 is a damping material capable of storing and dissipating high values of energy when stretched or sheared. It is a low viscosity liquid curing to an elastomer which is highly effective in controlling vibration.

A delayed action foam made by the same company is based on the chemical reaction of polyisocyanates with a specific organic compound at room temperature, which without pressure rapidly produces semi-rigid or rigid foams having controlled densities. The exothermic heat liberated is said to be less than one half of that commonly encountered with this type of foam—a factor important when considering heat-sensitive units. It is possible to obtain densities from 2 to 30 lb./cu.ft., and the resin will adhere to almost every type of surface without pretreatment.

The "Safetymaster" Power Tool made by Wolf Electric Tools Ltd., is an excellent example of modern power tool design. The cutaway section indicates the ingenious application of Beetle DMC material for double insulation.

Beetle Polyester DMC is used by Wolf Electric Tools Ltd., for *double insulating* their Safetymaster Power Tool. Mouldings in Beetle DMC have excellent anti-track and electrical insulation properties, good heat resistance and high mechanical strength. Compatibility with metals and dimensional stability are really outstanding for thermosetting materials. Beetle DMC is a *fast-curing* compound and can be moulded in conventional compression and transfer presses. Write for technical leaflets.

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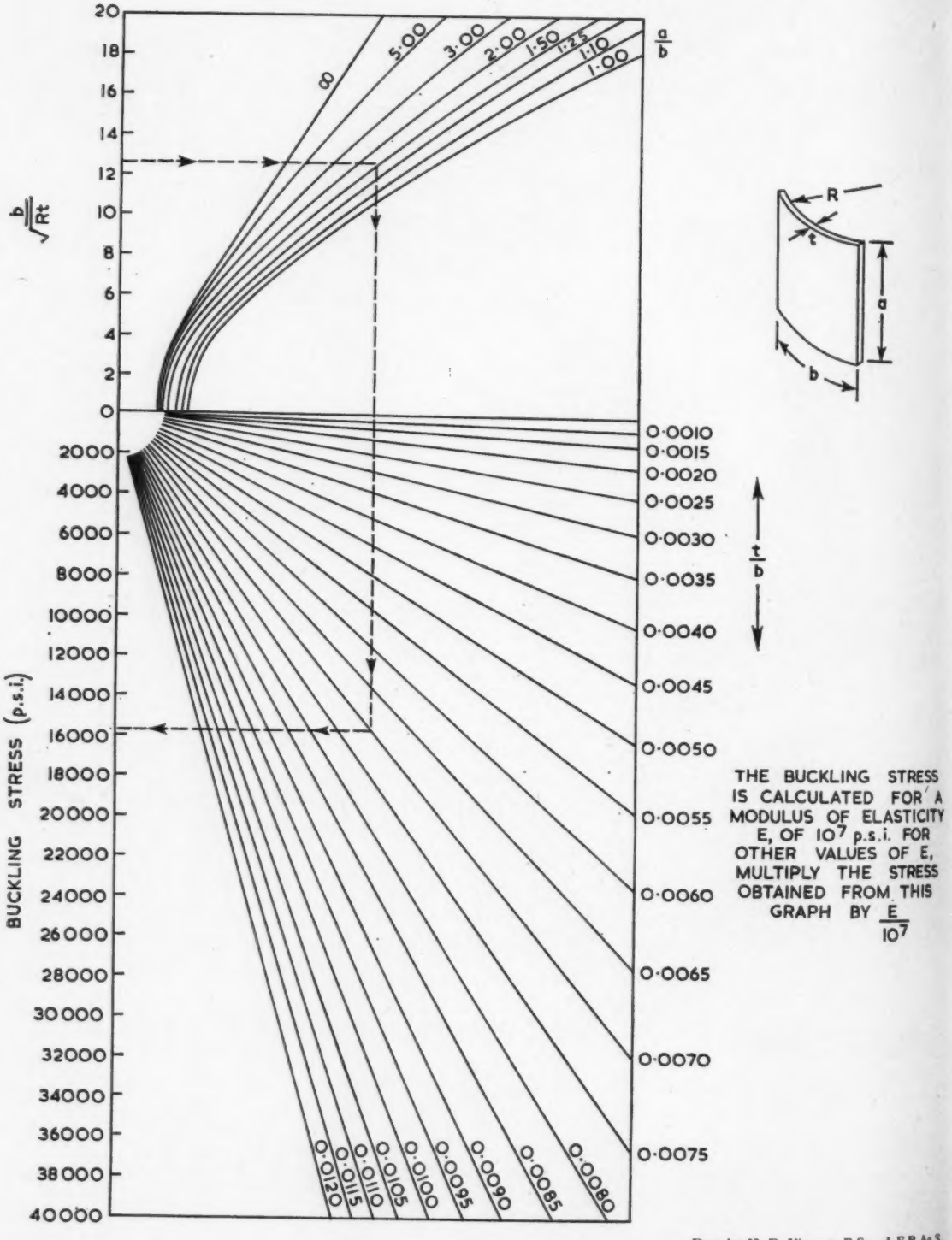
BUCKLING STRESSES OF CURVED PANELS IN SHEAR

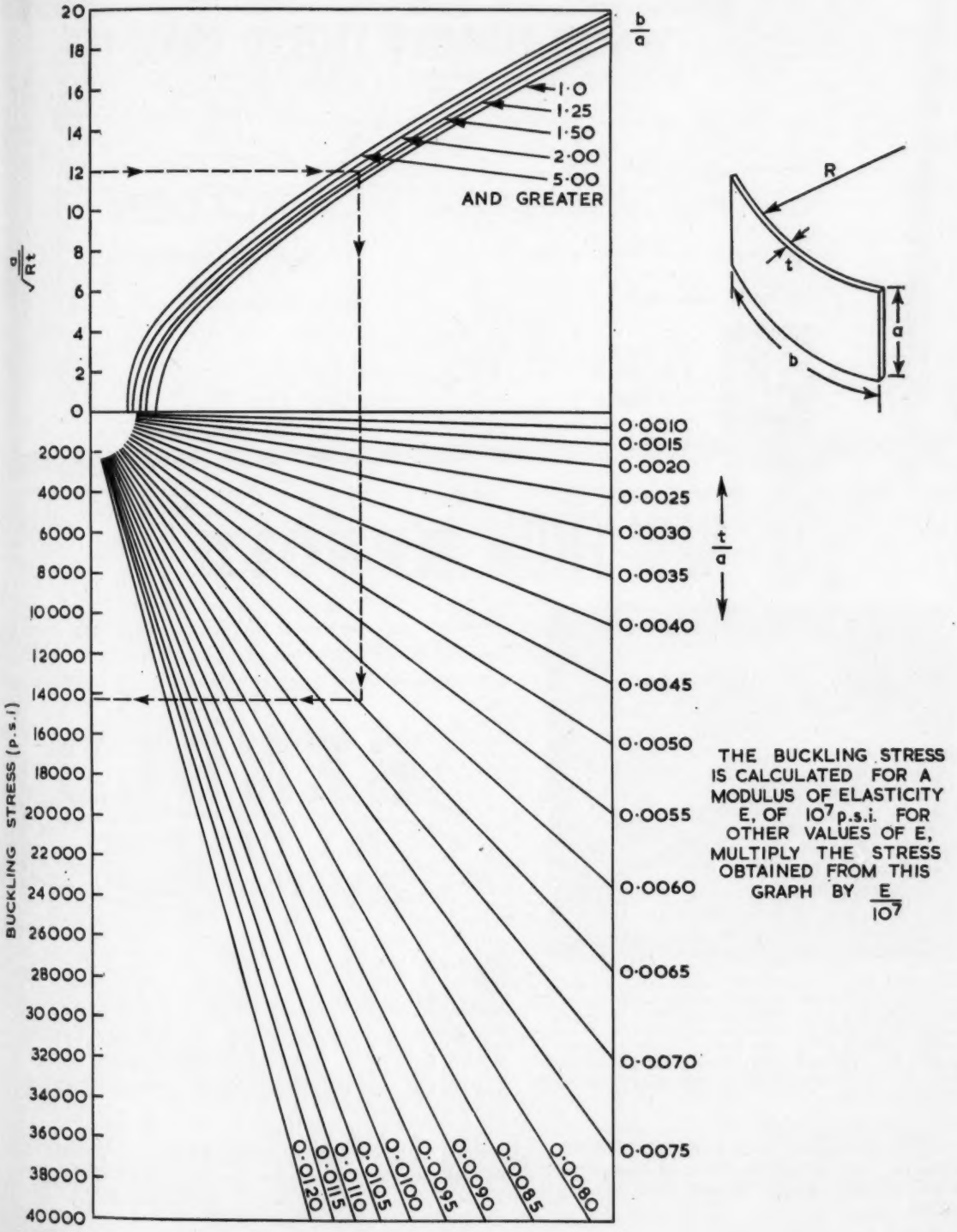
Engineering Materials and Design
DATA SHEET No. 64



THE BUCKLING STRESS IS CALCULATED FOR A MODULUS OF ELASTICITY E, OF 10^7 p.s.i. FOR OTHER VALUES OF E, MULTIPLY THE STRESS OBTAINED FROM THIS GRAPH BY $\frac{E}{10^7}$

Data by H. E. Vincent, B.Sc., A.F.R.Ae.S.

BUCKLING STRESSES OF CURVED PANELS IN SHEAR (contd.)



THE BUCKLING STRESS IS CALCULATED FOR A MODULUS OF ELASTICITY E, OF 10^7 p.s.i. FOR OTHER VALUES OF E, MULTIPLY THE STRESS OBTAINED FROM THIS GRAPH BY $\frac{E}{10^7}$

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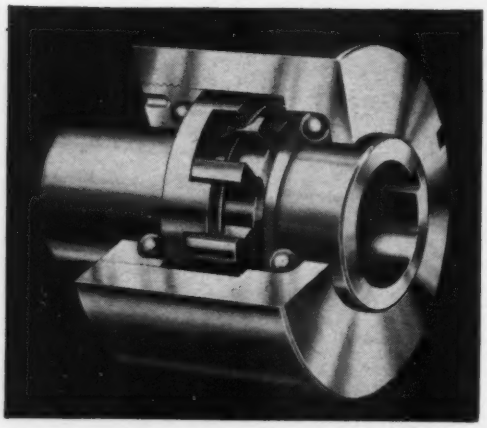

TYPICAL APPLICATIONS include conveyors and elevators, printing and packaging machines, mine cars, gear boxes, machine tools, and as a safety device for a wide variety of machinery; mechanical and electrical instruments, aircraft controls, radar and equipment requiring positive, accurate positioning; steering gear on marine and heavy vehicles and equipment requiring a mechanical protection device

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Engineering Materials and Design

DATA SHEET No. 65

To supplement the existing data, linear thermal expansion coefficient determinations at temperatures up to 1,500 deg. C. have recently been made on a number of industrially significant alloys. Specimens were in the form of $\frac{1}{4}$ in. dia. drawn rod, and were suspended vertically in a split tube resistance furnace. Two telemicroscopes were used to determine the changes in length between reference marks on the specimens originally 3 in. apart. The experiments were carried out in air.

The rods used for these tests were in the hard drawn condition when inserted into the cold furnace; it was found that annealing in situ induced permanent decreases in length. Some typical effects are illustrated in Fig. 1, which relates to the 20 per cent rhodium alloy. The first heating curve was fairly smooth up to 1,360 deg.C., after which decreases in length at constant temperature were observed. After one hour at 1,500 deg. C. the cooling curve was found to be appreciably lower than the first heating curve. Measurements at room temperature showed a permanent decrease in length of approximately 0·003 in. on the original 3 in. test length. Subsequent heating and cooling did not cause further appreciable changes in length.

All the alloys studied exhibited this shrinkage effect to some extent, and the expansion curves plotted in Fig. 2 are those obtained during cooling after approximately one hour at 1,500 deg. C. All the curves are similar in character, and agree fairly well with data for rhodium published by Ebert in 1938[1], and with data for pure platinum published by Holborn, Scheel and Henning in 1919[2]. Although the expansion coefficients appear to increase slightly with rhodium content the effect is not pronounced, and all the alloys tested expanded 16 to 18 $\times$ 10^{-3} in./in. over the range 0 to 1,500 deg. C. The 30% rhodium alloy expands somewhat less than its composition might suggest. The proportional changes in length of the alloys tested over the temperature range 0 to 1,500 deg. C. are summarised in the table at the foot of the page.

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1. H. Ebert, *Phys. Zeit*, 1938, 39, p. 6.
2. L. Holborn, K. Scheel and F. Henning, *Warmetabellen Braunschweig*, 1919, p. 54.

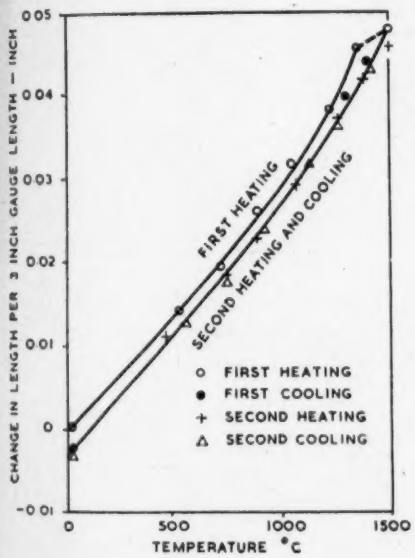


Fig. 1 (*left*). Permanent decrease in length caused by annealing (20% rhodium - platinum).

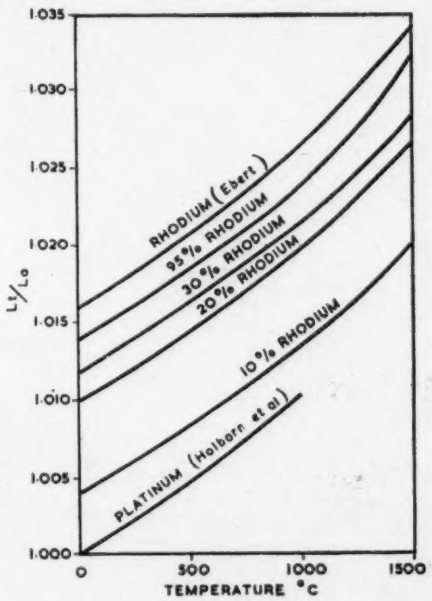
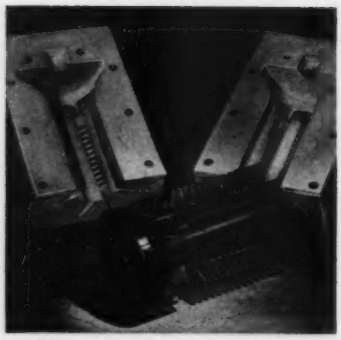


Fig. 2 (*right*). Thermal expansion characteristics of platinum, rhodium and some rhodium-platinum alloys.

$$\frac{Lt}{Lo} = \frac{\text{Expanded length}}{\text{Original length}}$$

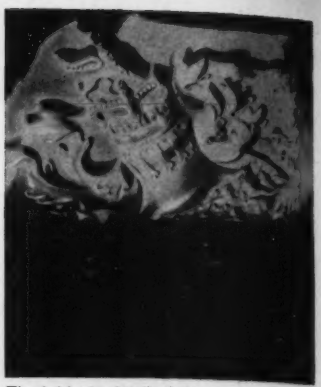
Temperature (°C.)	Platinum[2]	10% Rh	20% Rh	30% Rh	95% Rh	Rhodium[1]
0	1.000	1.000	1.000	1.000	1.000	1.000
100	1.00090	1.0010	1.00063	1.00092	1.00095	1.00085
200	1.00183	1.0020	1.00140	1.00170	1.00180	1.00180
300	1.00278	1.0030	1.0023	1.0027	1.0027	1.00280
400	1.00376	1.0041	1.0032	1.0035	1.0036	1.00385
500	1.00477	1.0051	1.0043	1.0045	1.0045	1.00490
600	1.00580	1.0061	1.0053	1.0054	1.0054	1.00600
700	1.00686	1.0072	1.0063	1.0064	1.0065	1.00710
800	1.00794	1.0083	1.0075	1.0075	1.0076	1.00825
900	1.00905	1.0094	1.0087	1.0085	1.0087	1.00950
1000	1.01019	1.0106	1.0099	1.0097	1.0100	1.01080
1100	—	1.0117	1.0112	1.0109	1.0113	1.01210
1200	—	1.0131	1.0125	1.0121	1.0128	1.01350
1300	—	1.0144	1.0138	1.0135	1.0146	1.01500
1400	—	1.0158	1.0152	1.0149	1.0164	1.01650
1500	—	1.0176	1.0167	1.0165	1.0184	1.01810

Data by courtesy of Johnson Matthey Ltd.



Flexible rubber moulds fabricated from Cold-Cure Silastomer are used for casting high-temperature curing epoxide resin coil formers.
Photograph courtesy Hivolt Ltd.

This is just one of a 100 cockerels which were produced from a one-piece Cold-Cure Silastomer mould.
Photograph courtesy Courage & Barclay Ltd.



The intricate detail of this coat of arms is faithfully reproduced by using a Cold-Cure Silastomer mould.
Photograph courtesy Pytram Ltd.

WELL CAUGHT....

the fine detail of this hand, cast in epoxide resin from a Cold-Cure Silastomer mould. The flexibility, ease of use and quick release properties of Silastomer were further reasons for choosing it to mould the cockerel, the coat of arms and coil-former, shown above.

What is Cold-Cure Silastomer?

A liquid silicone rubber which sets at room temperature, and produces flexible, easy to use, moulds that remain firm and stable up to 200°C.

What will it do?

Cold-Cure Silastomer reproduces the most intricate detail. The photographs above show some examples of what is being done—and the range is limitless.

Used to cast a variety of plastics, waxes, plaster and low melting point alloys, Cold-Cure Silastomer strips easily from these materials and is a quick, economical method of matching the original in every detail.

Midland Silicones already have wide experience of the many industrial applications of Cold-Cure Silastomer and can give expert advice on their many and varied uses.

Write or phone our nearest branch office and tell us about your problems. Also ask for our publication K28 and regular news bulletin: 'MS News for industry', which contains the latest news on the uses of all our products.

MSR11

SILASTOMER is the registered name for a comprehensive range of silicone rubbers manufactured and sold by Midland Silicones Ltd.

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New Books

Diffuse Coatings on Iron and Steel. *By N. S. Gorbunov.* (*Published for the Natural Science Foundation, Washington, D.C., by the Israel Program for Scientific Translations*—$1.75.)

THIS book deals with a highly specialised subject, and is based for a considerable part upon the work of the author and his collaborators at the Institute of Physical Chemistry, Academy of Sciences, U.S.S.R. In the Soviet Union, systematic investigations of this subject have been continuing since 1935. The book should be of interest to the reader who wishes to follow the progress made by the Soviets in the fields of science and technology.

The book commences with a discussion of the mathematical laws governing the probability of an atom's passage from one equilibrium state to another. The fundamental differential equations of diffusion are derived, then the physico-chemical conditions in the formation of diffuse coatings are discussed. Finally, the solubility of various elements in iron is determined. The second chapter is concerned with the numerous methods of forming diffuse coatings, and contains many diagrams. It is followed by a chapter on the diffusion coefficients of chromium in iron, the spectroscopic and radio active tracer methods being described. Chapter 4 (which is written by the author jointly with N. A. Shishakov, Doctor of Chemical Sciences) deals with the roentgens-graphical and the electron-diffraction analysis of diffuse coatings. The results of these analyses, which for the greater part refer to the chromium coatings at various temperatures, are given in the form of a series of tables.

The rest of the book (seven chapters) studies the diffuse coatings formed by copper, gold, zinc, beryllium, boron, aluminium, silicon, titanium, vanadium, chromium, molybdenum, tungsten, manganese and other chemical elements. For the purpose of systematisation the chapters are made to correspond to the groups (from the first to the seventh inclusive) of Mendeleev's periodic system of elements. The book is concluded with an extensive bibliography.

Typographically the book could be improved by increasing the size of certain portions of print (e.g. mathematical formulae and expressions). Similarly the quality of some of the photographs of metallic microstructures leaves something to be desired.

W. E. Sirk

The Fabrication of Tungsten. (*O.T.S. Publication PB* 151071—$1.75.)

THE outstanding strength of tungsten is illustrated in this book by a comparison of some of its significant physical properties with those of other metals. The effects produced by heating tungsten are also discussed. The most important of these changes is the ductile brittle transition at about 200 to 400 deg.C., and the effective recrystallisation temperature at about 1500 deg.C. or above. The consolidation of tungsten by powder metallurgy procedures and by arc melting is summarised. Considerations of importance such as primary working, secondary working and joining are also discussed.

Civil Engineering Reference Book. *Second edition, edited by J. Comrie.* (*Butterworths Scientific Publications, four volumes*—£17 17*s*.)

THE first edition of this reference book appeared in 1951, shortly after the death of its senior editor, Dr. E. H. Probst. It then amounted to 1,700 pages of text in fifty chapters. It now has been entirely revised, and the chapters have been rearranged in four volumes totalling about 2,100 pages, in the same format as the original book.

Half of the new material in the four volumes is in the chapter on dams and water power, by Dr. C. Jaeger. The remaining new chapters deal with overhead transmission lines, structural concrete, prestressed concrete, the aesthetics of bridge design, and masonry and brickwork. Some chapters have been deleted, and many of the remaining chapters of the old book have been rewritten and slightly expanded.

The present arrangement of chapters is a great improvement, because similar subjects are grouped as far as possible in one volume. Volume 1, on the fundamentals of civil engineering, includes mathematics; statistics; physics and chemistry; mechanics; the mechanics of fluids; strength of materials; thin slabs and shells; surveying; building materials; cements; measurements in field testing; and general tables. Volume 2 deals with all aspects of excavation, including soil mechanics and foundations (three chapters, 180 pages); dams and water power; British tunnelling practice; Swiss tunnelling practice; land drainage; explosives; overhead transmission lines; canal and river hydraulics; and coastal engineering.

Volume 3 deals only with structures (superstructures) and structural materials, including theory of structures; concrete, reinforced, prestressed and precast; iron, steel, including welding; light alloy; timber; masonry, bridges, and the aesthetics of bridges. Volume 4, on means of communication, concerns waterways; highways; airports; railways; harbours, sewerage and sewage disposal; town planning; contractor's work; specifications and quantities; fire protection of buildings; and legal information, including patents.

These books contain more information probably than any other civil engineering reference work in English, much of the information being condensed into tables. The individual authors are well known, and are in most cases the most eminent British or American engineer in the field covered by their chapter.

J. Scott

U.S.A. TECHNICAL REPORTS

Unless otherwise stated, these reports can be obtained from O.T.S., Department of Commerce, Washington 25, D.C.

Welding of Columbium and Columbium Alloys. *Battelle Memorial Institute* (*PB* 161,219).

Effect of Individual Lamination Thickness on the Strength of Curved and Straight Oak Beams containing Cross Grain. (*PB* 171,174—$1.25).

Design Information on 5% Cr, Mo, V Alloy Steels for Aircraft and Missiles. (*PB* 151,072—*R*) $1.50.

Moulded Composites for Boat Hulls. *U.S. Government Research Report* (*PB* 171,168)—$1.25.

Joining of Tungsten. *Battelle Memorial Institute* (*PB* 161,224).

Selected Short Time Tensile and Creep Data obtained under Conditions of Rapid Heating. (*PB* 151,088)—$2.25.

Investigation of Bearing Creep of Two Forged Aluminium Alloys. *National Bureau of Standards* (*PB* 161,556)—$1.00.

OTHER BOOKS RECEIVED

BS 1134:1961. (*British Standards Institution*—8*s*. 6*d*.).

Gives the principles by which irregularities of machined and other surfaces can be assessed numerically, and includes details of measuring techniques.

BS 2004:1961. (*British Standards Institution*—7*s*. 6*d*.).

Specifies dimensions and test requirements for p.v.c. insulated cable and flexible cords, for up to 660 volts.

BS 3146, Pt. 2:1961. (*British Standards Institution*—8*s*. 6*d*.).

Specifies eighteen types of investment-casting materials in high alloy steels, nickel and cobalt alloys.

BS 3318:1961. (*British Standards Institution*—5*s*.).

Indicates methods of determining the centre of gravity of large components or assemblies, such as tractors. A method of determining the overturning angle is included.

BS 3332:1961. (*British Standards Institution*—5*s*.).

Specifies the chemical composition of nine white-metal bearing alloys in ingot form.

BS 3333:1961. (*British Standards Institution*—4*s*. 6*d*.).

Describing the composition, processing and mechanical properties of two grades of pearlitic malleable iron castings.

BS 3346:1961. (*British Standards Institution*—8*s*. 6*d*.).

Specifies dimensions and test requirements for p.v.c. insulated cables protected with galvanised steel wire armour.

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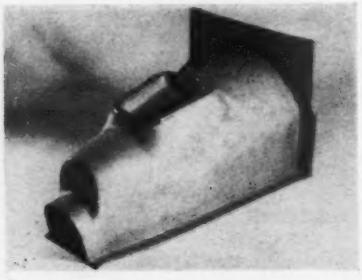
Highlights from the INTERNATIONAL PLASTICS EXHIBITION & CONVENTION

OLYMPIA · LONDON · JUNE 21 to JULY 1 · 1961

Fibre Moulded Gear Box Cover

The car industry is looking with increasing interest at preformed moulded fibre components. These achieve the properties of the plastics and the strength of the fibres in a unique way. Unlike the usual fabric laminates with shaping limitations, the individual fibres are mixed with resins, and can be preformed into any shape before moulding. Typical examples from the motor industry include instrument cowls, glove boxes, demister nozzles and gearbox covers (see illustration), the latter now in quantity production.

Moulded fibre combines the advantages of lightness, sound absorption and resistance to impact. A wide range of finishes can be applied, including lacquer, enamel, flock spray, leather, leatherette and p.v.c. *Hawley Products Ltd.*, Garman Road, Park Estate, Tottenham, London, N.17.



EMD 7257 for further information

Coating Metal Components

It is frequently necessary to protect metal components from corrosion by the application of resistant coatings. A variety of materials can be used for this purpose, including p.v.c., p.t.f.e., nylon, p.t.f.c.e., and polythene.

Some typical examples of products treated in this way were on show, including a 5-ton salt water pump (the top half being dip lined with p.v.c.—¼-in. coat), and a large chemical stirrer paddle with a $\frac{3}{16}$-in. seamless coating of p.v.c. (giving an extremely good bond). It is sometimes difficult to obtain satisfactory bonds with such products, but special primers were used in the instances described.

A considerable amount of pipe work is coated with p.v.c. and p.t.f.e. is applied to give non-stick release surfaces, for which purposes thicknesses of only 0·0005 to 0·002 in. are required. The p.t.f.e. should not, however, be used as an anti-corrosive finish because of microporosity, and the chemically related p.t.f.c.e. is preferred for such purposes.

Nylon coatings are used to give high gloss durable finishes, and are an ideal replacement for chromium plating. Costs are greatly reduced since no expensive metal preparation is required, and metal chairs coated with 0·025-in. nylon are said to readily withstand the high abrasion of stacking. *Plastic Coatings Ltd.*, Woodbridge Industrial Estate By-Pass, Guildford, Surrey.

EMD 7258 for further information

Epophen Plastics Tools

Epophen is an epoxide resin which sets to a very hard composition used in the making of certain tools, jigs and fixtures. The resins can be cast, laminated, or otherwise moulded to predetermined shapes, and since the shrinkage on cure is negligible there is no need for the expensive machining and hand-working operations which make conventional tools relatively expensive to produce.

Although these plastics tools can be quite satisfactory, they are not, of course, as strong as steel, so that usually they deteriorate relatively rapidly, particularly where high pressures are involved; they are best used for short runs or for prototype purposes.

Metal forming tools can be readily made from Epophen, such as stretch-press formers; spinning chucks; hammer forms (beating blocks); drop hammer tools, rubber press tools; and multi-part press tools used as draw dies in single- or double-action presses. Most metals can be formed, although limitations may arise, especially with the stronger sheet metals when these are thicker than about 18 s.w.g. Similarly, sharp radii of less than $\frac{3}{16}$ in. in 20 s.w.g. may put too severe a strain on the plastics tooling compositions. Drill jigs, router jigs, checking fixtures, welding fixtures, and foundry patterns can also be easily made in Epophen resins. *Leicester, Lovell & Co. Ltd.*, North Baddesley, Southampton.

EMD 7259 for further information

Hetron Resin

Polyester resins are well known as engineering materials, but unfortunately their fire resistance is not all that is required for some purposes. The Hetron polyester resins are a new chemical type of resin which give the necessary flame resistance.

The resins are used for making laminates, and give a high impact strength and good flame retardance. The materials do burn, like most organic substances, but they are self-extinguishing on removal of the flame. The materials also have good chemical resistance, and when used in conjunction with glass cloth have excellent flexural strength and low water absorption.

Some properties of the unfilled casting include: a heat distortion point of 130 deg.C.; tensile strength of 3,000 p.s.i.; flexural strength of 8,000 p.s.i.; dielectric constant of 3·12; and power factor at 10^6 c/s of 0·0043. *Albright & Wilson (Mfg.) Ltd.*, 1 Knightsbridge Green, London, S.W.1.

EMD 7260 for further information

Pre-impregnated Tyglas

Manufacturers are accustomed to purchasing ready-made laminates, but much can be accomplished by laminating in situ. Usually this is a very troublesome process, since it involved winding a layer of glass woven fabric round the object concerned, bonding with a suitable resin, applying further glass fabric, more resin, and so on.

A special pre-impregnated glass fabric has been devised which has already been treated with resin and requires no further application of material. This product is available in roll form interleaved with a polythene film. The lay-up of parts to be moulded is helped by the controlled tack of the material, which will stick to itself but not to the operator's fingers. The material will drape readily and thus conform easily to complex curvatures. Easy mouldability is achieved through uniform resin dispersion and optimum flow properties, which also ensure short cure cycles.

The illustration shows an air gas valve for Vickers Valiant, in which are embedded a number of heating elements.

The shelf life of the material is about four months, and good physical properties can be obtained. These include a tensile strength of 50,000 p.s.i. and a flexural strength of 55,000 to 70,000 p.s.i., depending on materials and conditions. These results are well maintained in boiling water, and electrical results are also good, with the power factor at 0·012 and the dielectric constant at 3·36. *Fothergill & Harvey Ltd.*, Littleborough, Lancs.

EMD 7261 for further information

Highlights from the INTERNATIONAL PLASTICS EXHIBITION & CONVENTION

Polyurethane Foams

There are a number of foamed plastics on the market today which are proving to be extremely valuable engineering materials. These can not only be purchased as sheets or blocks of flexible or rigid foams, but can also be obtained in the fluid state so that they can be poured into cavities and foamed in situ. Examples of this type are rigid foams based on Daltolac 21, 22 and 24. When the polyester (Daltolac 21) and the cross linking isocyanate (Suprasec D) are mixed they give the strongest product of the series, and produce a foam having a density of 8 lb./cu. ft., a compression modulus of about 4,500 p.s.i., and a compression strength of 150 p.s.i.

Foams of this density and structure are quite strong, and between sheets of metal, wood or plastics they form very strong laminates which can be used in stressed structures to give valuable thermal insulating properties. Introduced into cavities they impart rigidity to the whole, since they adhere strongly to the enclosing walls. By using Daltolac 22 and 24 it is possible to obtain foams with densities of 3 and 2 lb./cu. ft. respectively. These are, of course, softer than the previously described foam, and have a compression strength of only 20-25 p.s.i.

These materials have already found a considerable application in the thermal insulation of land cold-stores; refrigerated ships; partitions; low-weight high-strength doors; insulated vans and lorries; caravans; and insulated road tankers.

Daltolac 41 *Foams*

Although most foams look very similar, they often have quite different methods of application, or different properties. The I.C.I. series includes a urethane foam employing Suprasec D in the usual way, and a polyether composition under the trade name Daltolac 41. When the two are mixed together, the composition froths up and sets rapidly, forming a rigid foam of several times the original volume. The foam can also be sprayed from a multi-mix spray gun, which makes the method of application very flexible indeed.

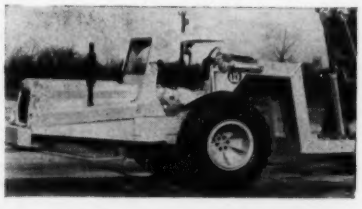
As distinct from the foams based on Daltolacs 21, 22 and 24, all the cells are closed or sealed, so that the material is completely impermeable to water and has a low water vapour transmission coefficient. In a three months immersion test, the water uptake was only 2 per cent (for a sprayed foam), and thicknesses up to ½ in. can be made at a single pass. The compression strength is 50 p.s.i., and the thermal transfer value is 0·24 B.t.u./sq. ft./1 in. thickness/deg.F. at 0 deg.C.

Bulk dispersed foams are usually of lower density than sprayed foam, the density varying from 1·5 to 4·0 lb./cu. ft., and the compressive strengths being between 15 and 25 p.s.i. Three months immersion of these bulk foams in water gave an uptake of water of only 0·7 per cent by volume. *I.C.I. Ltd.*, Dyestuffs Division, Hexagon House, Blackley, Manchester.

EMD 7262 for further information

Crystic Polyesters

Crystic 196 polyester is particularly valuable in the manufacture of glass fibre reinforced plastics in applications where toughness and rigidity are important. It is suitable for contact moulding by both the hand laying up and spraying techniques. It wets the glass fibre reinforcement thoroughly and rapidly, and sets quickly so that short moulding cycles are possible.



Crystic 196 is weather resistant, and because of this has become widely accepted in the transport industries, where it is used extensively for moulding the coachwork of lorries, vans, buses and coaches. The cab, wings and bonnet of the Dinkum Dumper illustrated are contact moulded in this material by Whitlock Bros. Ltd. *Scott, Bader & Co. Ltd.*, Wallaston, Wellingborough, Northants.

EMD 7263 for further information

Aclar Films

Aclar fluorohalocarbon film is an unusual material which contains no plasticisers, fillers or other additives. It has a remarkable combination of properties, and although still only in pilot plant production, is likely to be of great value.

The films are said to be remain flexible down to −96 deg.C., and to retain some useful properties up to temperatures as high as 200 deg.C. The material is transparent, has no moisture absorption, and has extremely low permeability to moisture vapour and other gases.

The electrical properties of the film are good, with low power factor and dielectric constant, and high volume and surface resistivity. Chemical properties are also good, and the material is not attacked by inorganic acids, alkalis, oxidising acids and most organic solvents.

Aclar is non-inflammable, and has a tensile strength ranging from 8,000 to 13,000 p.s.i., depending on the type. It can be readily sealed by h.f. currents, and can be sterilised without distortion. *Kingsley & Keith (Chemicals) Ltd.*, Rex House, 38 King William Street, London, E.C.4.

EMD 7264 for further information

Cycolac Plastics

Cycolac is a member of the family of thermoplastic resins known as ABS (acrylonitrile butadiene-styrene). The unique combination of properties of this material has extended its use into a wide field. In particular, it has good electrical properties; good resistance to chemicals, a specific gravity as low as 1·02; a wide colour range; excellent dimensional stability; unusual hardness for a thermoplastic material; and toughness and rigidity.

There are a number of grades of the material—Cycolac H, L, T, X7, and C. Type H has maximum toughness; Type L has maximum toughness at low temperatures; Type T has toughness with maximum flow characteristics; Type X7 has high heat resistance; and Type C is particularly suitable for pipes. Tensile strengths range from 2,900 to 4,700 p.s.i., with Rockwell hardness ranging from R.86 up to R.108. The water absorption for all materials is only 0·2 to 0·3 per cent increase after 24 hr. immersion at 23 deg.C. Electrical properties are good—the power factor is 0·005 at 60 c/s, increasing to 0·008 at 10^6 c/s.

These materials have already been used for a wide number of applications, such as automobile-dash panels; typewriter housings; mouldings to contain instrument clusters; refrigerator door liners; wall telephones; refrigerator car liners; food carriers; and pipes. In the latter connection much rigid thermoplastic piping has been used for conveying water underground. *Anchor Chemical Co. Ltd.*, Clayton, Manchester, 11.

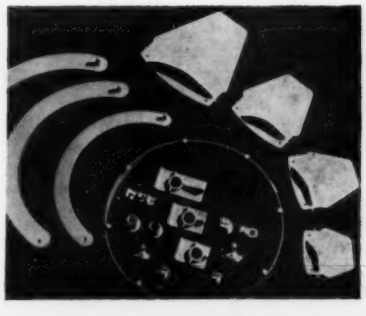
EMD 7265 for further information

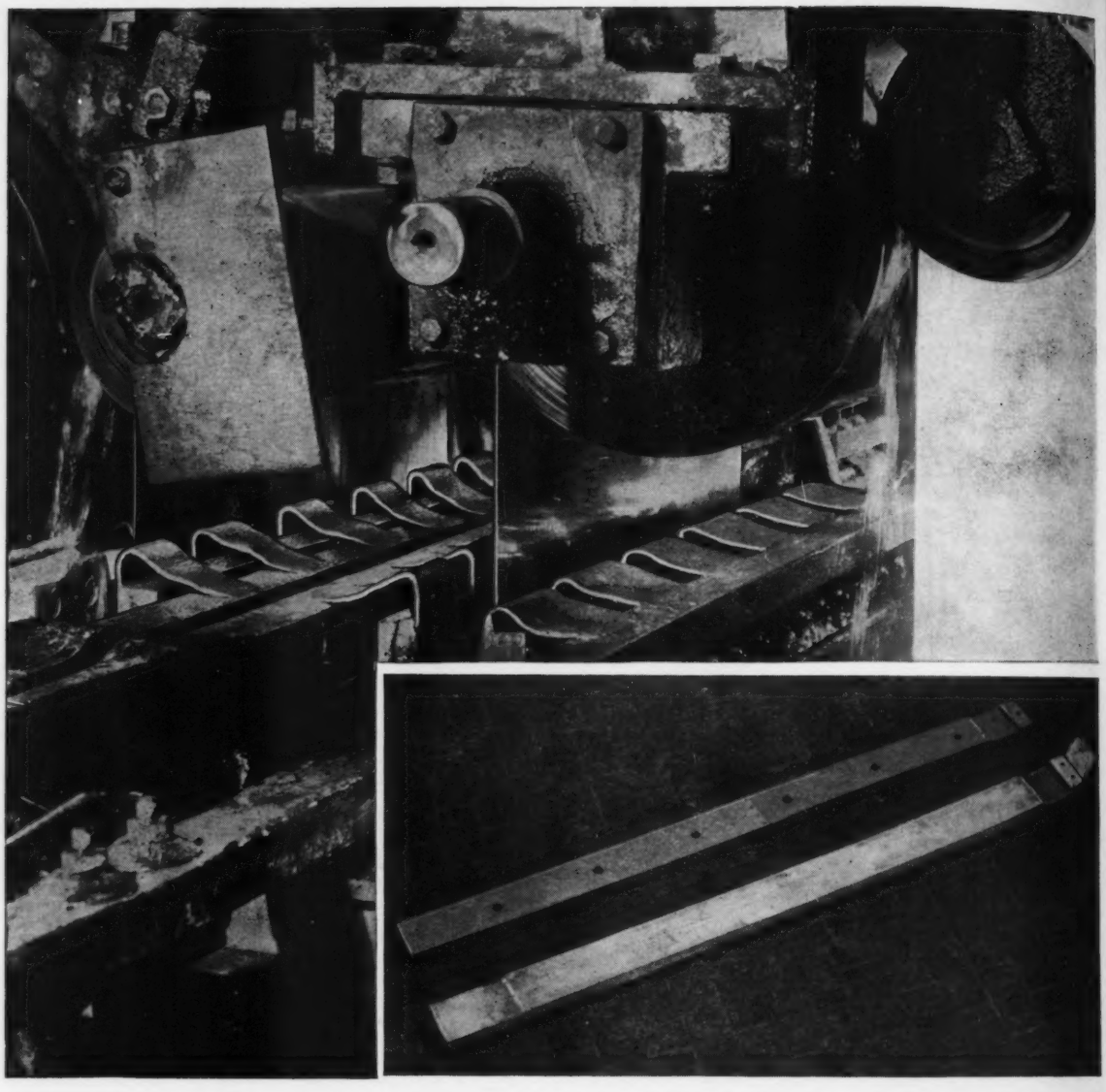
Delrin—New Plastics

Delrin is a new plastics known as a linear acetal resin. It is a highly-crystalline high-melting thermoplastic polymer which is almost as strong as non-ferrous metals. The material is rigid without being brittle and is tough and resilient, rather like spring steel. It retains these properties at elevated temperatures, is 85 per cent lighter than brass and 45 per cent lighter than aluminium. It can be fabricated by conventional methods and machined easier than brass, as shown by these parts in the new Vent-Axia ventilating unit.

Delrin has already been employed in many engineering applications, and has withstood a severe test as a speedometer gear shaft. *Du Pont Co. (United Kingdom) Ltd.*, 76 Jermyn Street, London, S.W.1.

EMD 7266 for further information





Why the Steel Company of Wales relies on TUFNOL for anode cores

For more than two years the Trostre works of the Steel Company of Wales has been using lead covered "Whale" Brand Tufnol anode cores with great success in Electrolytic Pickling Tanks.

They lower the cost of the anodes by reducing the amount of lead required. This in turn saves weight and makes for easier handling. Stoppages are reduced and maintenance costs cut because the anodes are more rigid and robust, and the cores can be recovered.

This use for Tufnol in the plate industry can be extended with equal success to similar applications.

There are eleven other brands of Tufnol, available in sheets, tubes, rods, angles and channels. All brands are laminated plastics; each formulated to satisfy specific requirements. Your local Tufnol Branch Office will gladly supply you with further information.

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Highlights from the INTERNATIONAL PLASTICS EXHIBITION & CONVENTION

Ralsin Nylon

Nylon is well known as an engineering material, but new types are continually being developed. Ralsin is a special material having exceptional resistance to abrasion and corrosion, which make it suitable for a wide variety of applications. This material is said to withstand temperatures from −40 to +130 deg.C.; it is almost unbreakable, and has a high resistance to a wide variety of chemicals. It can be used as a coating material, and as such was shown as a lining for valves, but it can also be used on interior and exterior metal work.

A number of products for the engineering industry were also on show. These included precision-made gears, door catches, casings and sealing rings. One advantage in some of these applications of Ralsin is that it is claimed to have lower water absorption than any other nylon.

In addition to use in products of this kind, it can be made into strong lightweight tubes, and these were also on display. The pipes can be extruded to extremely low tolerances, and high pressure Ralsin hose is replacing metal tubes for brake hose on many modern cars. Tube for fuel lines was also exhibited. *Whiffen & Son Ltd.*, Willows Works, Derby Road, Loughborough, Leicestershire.

EMD 7267 for further information

P.t.f.e. Pipe-lines

The larger of the three coils shown in the accompanying illustration is a ten-strand multi-coloured plastics-bonded electrical wiring "harness". Below this is a smaller reel of pure p.t.f.e. tape and a reel of fibreglass tape, both of which are utilised in the manufacture of flexible pipelines for carrying corrosive liquids and for hydraulic applications.

Very flexible stainless-steel or lightweight alloy armoured p.t.f.e. pipe-lines

can be produced in a range of diameters up to 20 ft. in length. Suitable end couplings to suit specific requirements can also be provided.

Helically convoluted hoses for use as cable conduit (e.g. for applications where it is necessary to protect wiring cables from corrosive atmospheres or liquids) can be manufactured to customers requirements, and such an item is shown here encasing a number of plastics pipelines, all of which have screw connector couplings fitted. *Uni-Tubes Ltd.*, Summit House, 1-2 Langham Place, London, W.1.

EMD 7268 for further information

Plastics Pipe Fittings

The use of plastics pipes is expanding rapidly in all branches of industry. They are now available in a variety of materials and the necessary fittings are also being produced.

Durapipe extrude piping in bores ranging from $\frac{3}{8}$ to 6 in., and in three materials: Durapipe K (ABS copolymer); Durapipe V (high-impact p.v.c.); and Durapipe Z (high-density Ziegler polyethylene). All of these pipes are available in light, normal and heavy gauges.

In addition to the pipes, Durapipe exhibited all their range of 450 moulded pipe fittings. These include tees, elbows, sockets, flanges and saddles. The 6 in. moulded fittings are claimed to be the largest of their type available in Europe.

In addition to threaded fittings jointed in the usual way, plain fittings are also available for solvent welding. Such fittings are made to give an interference fit, and the joint may readily be made by applying the solvent cement to the inside and outside of the two pipes to be joined respectively. It is claimed that a mechanically strong joint results within 15 min., and that full pressures can be applied within 24 hr. *Durapipe & Fittings Ltd.*, Durapipe Works, West Drayton, Middlesex.

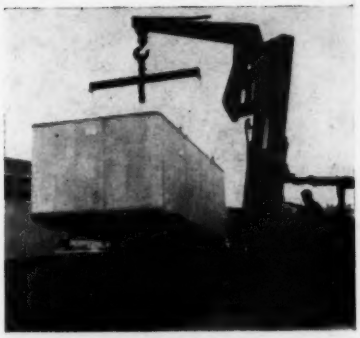
EMD 7269 for further information

Spraying P.v.c.

In using the protective properties of p.v.c., it is possible for manufacturers to spray on protective coatings themselves rather than have outside firms do it for them. Spray equipment for this purpose consists of a spray gun, air cap, fluid tip, needle and pressure cup. Suitable materials include the Vinatex P.S.P. series of pastes, which cure to hardnesses of 80 to 100° Shore. The pastes are supplied at a viscosity too high for spraying, so that it is necessary to dilute them to obtain a suitable consistency. Thinners ST.8 is designed for the P.S.P.80 pastes, and thinners ST.7 for the P.S.P. 100 pastes.

It is only necessary to clean and degrease the surface to be sprayed, which can include mild steel, stainless steel, chromium plate, tin plate, aluminium and glass. *Vinatex Ltd.*, Devonshire Road, Carshalton, Surrey.

EMD 7270 for further information



Epoch Reinforced Plastics

Glass reinforced fabrics are being used for a wide variety of purposes, but Epoch materials employing high strength glass, acrylic fibre and thermoplastic epoxide resins give "all-through" corrosion resistance as well as strength. Epoch pipes and fittings are available in sizes from 4 to 36 in. bore, and can be used at temperatures up to 140 deg.C. Standard lengths are 20 ft. of straight pipe, and there is a standard range of bends and tees. Special jointing materials are available, and it is claimed that three men can lay 200 ft. of pipe in 1 hr.

In addition to the manufacture of pipes, many other products can be made with these materials, including car bodies, boat hulls, large storage tanks, aircraft ducting, press tools and bend blocks. A particularly impressive example is the chemical storage tank supplied to the U.K. Atomic Energy Authority for the storage of radioactive effluents. A useful feature of these tanks is that because of their light weight they are easily handled without the use of elaborate equipment. *Bristol Aeroplane Plastics Ltd.*, Filton House, Bristol.

EMD 7271 for further information

Kopex Pliable Ducting

This material is rather different to the usual extruded plastics tubing, and is used for domestic and industrial heating and ventilating systems. Its great advantages, especially in intricate layouts, are its pliability, ease of coating, and simple cutting and fixing on site. It is easily bent by hand even to small radii, without distortion

Kopex tubing is formed from strip material such as steel, aluminium, paper or any combination thereof, and is made on a spiral machine. The metal is interlayered with bitumenised paper, fire resistant where necessary. The standard materials are lead-coated steel, aluminium (0·005 in. thick), and paper (0·005 to 0·008 in. thick).

The sizes of tubing available range from $1\frac{1}{2}$ to $7\frac{1}{2}$ in. i.d., continuous lengths being available if required. It is the spiral construction which allows bending without distortion, and which also allows ease of transport in coils. There is greater frictional resistance to flow and liquids than is the case with smooth bore metals, but this is normally offset by more streamlined bends—however, the manufacturer gives a formula for calculating friction loss. *Uni-Tubes Ltd.*, Summit House, 1-2 Langham Place, London, W.1.

EMD 7272 for further information

FEROGLAS

glass reinforced plastics

Today there's an ever-increasing use for FEROGLAS glass-reinforced plastics. FEROGLAS is a combination of Polyester, Epoxide or Phenolic resin reinforced with glass fibres, and has high strength/weight ratio and impact strength. Its dimensional stability, good weather and corrosion resistance and electrical properties also contribute to its frequent superiority in economy and durability to more conventional materials.

Specialists in press moulding, J. W. Roberts Ltd. have recently expanded with growing demands of industry and can now produce FEROGLAS components in a wide variety of sizes and shapes—*to meet individual requirements.*

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WHAT'S NEW IN MATERIALS

Polyether Foam

Crestafoam is a new flexible micro-cellular material which has been developed primarily for cushioning. It is claimed to be lighter and stronger than latex foam, and will not crumple or collapse. It can be stitched, stapled or fastened by any common method, and it is available in four grades of hardness. *Microcell Ltd.*, 9 Kingsway, London, W.C.2.

EMD 7213 for further information

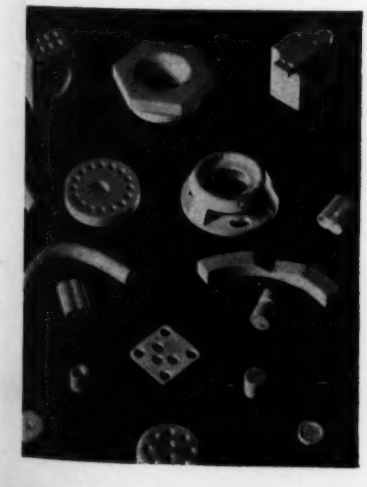
Ceramic in difficult Shapes

The development of new techniques and manufacturing methods is reflected in an ever-growing range of components for which Hylumina ceramic is suitable. The production in ceramic of many of the components shown here has become possible solely as a result of an advance in manufacturing methods.

In atomic engineering, Hylumina is used for the manufacture of thermal discs supplied for use inside nuclear reactors to insulate the uranium fuel element from the ends of the magnesium can. A material with a suitable neutron absorption is necessary under such conditions, hence its use also for a variety of support jigs, and test pieces against which the susceptibility of other materials to irradiation can be measured. The stability of this ceramic at high temperatures and under irradiation has led to its use outside the reactor in many applications, such as in lead-through terminals for heat-exchange pressure vessels.

Among the interesting shapes now being made in Hylumina for the first time are cathode supports, and an externally threaded nozzle used in slag separation at power stations. Other typical ceramic components include nozzles for agricultural sprayers and shot-blasting, thread guides for the textile industry, wire guides and pulleys. Igniters for oil burners, and probes for depth and flame control are further examples. *K.L.G. Sparking Plugs Ltd.*, Putney Vale, London, S.W.15.

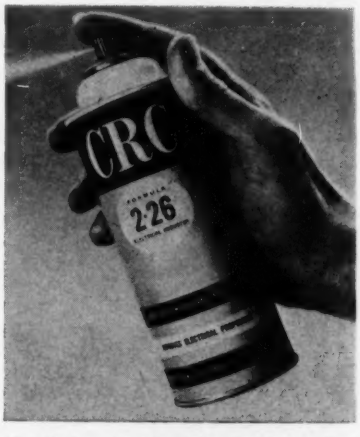
EMD 7214 for further information



Anti-corrosion Spray

CRC. 2.26 is a simple but effective anti-corrosion and anti-moisture treatment for electrical and electronic equipment. It is said to be able to penetrate pores, cracks or holes and displace absorbed moisture. After driving the moisture out, it forms a film to prevent further contamination. This film does not become brittle or crack, and is claimed to be an excellent corrosion inhibitor for metallic surfaces.

CRC. 2.26 also has a beneficial lubricating effect on moving parts. It is supplied in a 16 oz. aerosol dispenser, and can readily be used on the production line. It is also available in 1- and 5-gall. cans and



55-gall. drums for brushing and immersion. *Hellermann Ltd.*, Bowthorpe Electric Co. Ltd., Crawley, Sussex.

EMD 7215 for further information

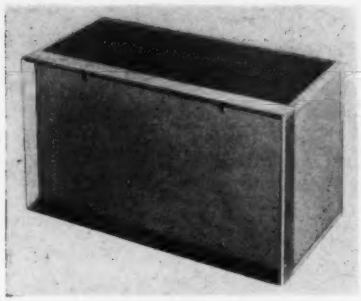
Protective Paper

Contor is a new material which combines a lightly impregnated flatback paper with a rubber-based adhesive. The paper has good strength characteristics, and the adhesive (a rubber Latex resin) gives the low adhesion required for easy removal from a variety of smooth surfaces, leaving no deposit or stain.

The paper is resilient enough to resist abrasion while protecting a smooth flat surface, and is designed to retain this property while the protected material is subjected to further production processes such as forming, drawing and other types of pressing. There is a "two-stage" protection whereby even after the paper splits there is left a resilient and cohesive film to protect the surface.

Contor protective paper is specified for the protection of stainless steel, chrome steel, polished and anodised aluminium, and various other materials including plastics laminates. The surface is such that it can be rubber stamped or written upon, thus facilitating identification and marking out. *John Gosheron & Co. Ltd.*, The Packaging and Industrial Tape Centre, Albert Embankment, Vauxhall, London, S.E.11.

EMD 7216 for further information



Miniature Imlok

A new construction system, Miniature Imlok, is based on the established principles of the Imlok Construction System (a series of die-cast aluminium connectors and interlocking aluminium extrusions) but is to a new design. While it is ideally suitable for the construction of units as small as 4¼ in. cube, it is equally suitable for much larger structures.

Initially there is a choice of twelve extrusions and two connectors. These extrusions offer a wide choice in the appearance of the finished framework. They cater for recessed panels, glass and other panels up to ¾ in. thick, and door frames, besides the normal external framework, which has a panel retaining groove for 20 s.w.g. panels. There are also a series of spacer bar extrusions to permit large panel areas to be broken up. Most of the extrusions are "square" in appearance.

The photograph shows a small instrument case with a recessed front panel, made from extrusions IM.802 and IM.806 used in conjunction with connectors IM.901 and IM.90. *Alfred Imhof Ltd.*, Ashley Works, Cowley Mill Road, Uxbridge, Middlesex.

EMD 7217 for further information

Rare Earth Metals

Supplies of scandium, yttrium and most of the fourteen rare earth metals are now available in sheet form, in thicknesses down to 0·001 in. and with a maximum width of 3 in., either cold worked or annealed. This is the latest development in the company's production of the metals of this group, which have previously been available as ingots and in some cases as wire of diameters down to 0·02 in. *Johnson, Matthey & Co. Ltd.*, 73-83 Hatton Garden, London, E.C.1.

EMD 7218 for further information

Absorbent Paper

A new product called Wipeclene consists of absorbent tissue supplied in 275-ft. rolls 10 in. wide, for industrial purposes.. It is recommended for wiping and cleaning jobs in factories, engineering shops and garages, but not for use with water.

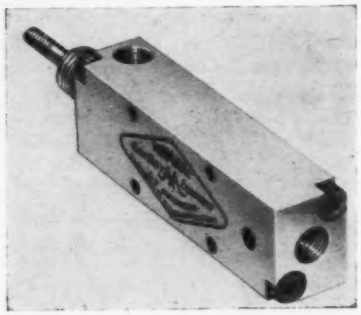
The rolls are packed twenty-four to a carton, and are used in conjunction with a white enamel dispenser. This container can be screwed onto any wall in a convenient position for operators to tear off the paper on a perforating edge incorporated in the unit. *Kittybrewster (Paper) Ltd.*, 88-90 Chancery Lane, London, W.C.2.

EMD 7219 for further information

WHAT'S NEW IN COMPONENTS

Rectangular Air Cylinder

A new ¼ in. bore air cylinder has a rectangular section brass body and ⅛ in. BSP ports. It is available in stroke lengths of ½ to 1½ in., and in single-acting, double-acting, and single-acting spring-return models.



This cylinder is provided with screwed nose mounting, and with fixing holes through the body to provide for side or base mounting, and also with provision for rear trunnion mounting—all as standard. The piston rod is of stainless steel, and the rod and piston seals are neoprene distributor-type U seals. No O rings are used in the cylinder, which is therefore capable of operating at fast speeds under light operating pressure and with a minimum of stiction. A midget flow-control valve (No. A70M) is available for speed control. *Air Automation*, 26 Sharrocks Street, Wolverhampton.

EMD 7220 for further information

New Villiers and JAP Light-Weight Engines

Preliminary details have been revealed of an entirely new range of Villiers and JAP high-performance lightweight four-stroke agricultural and industrial engines. This new range will include models for both horizontal-shaft and vertical-shaft applications, and cover capacities from 50 to 150 c.c. with power ratings from ¾ to 3½ b.h.p.

First of the range to go into production is a 50 c.c. unit—a single-cylinder blower-cooled horizontal-shaft engine developing 0·92 b.h.p. at 4,000 r.p.m. Suitable for a wide range of applications, this engine is designed on the "over square" principle, with a bore of 43 mm. and a stroke of 34 mm.

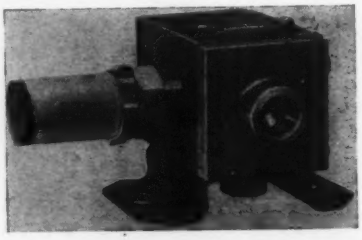
Weighing only 14 lb., it is neat and compact and the main components—cylinder block, cylinder head, crankcase cover, fan and blower casing—are all light-alloy pressure diecastings. Crankcase and cylinder block are cast as one unit, and the cylinder head is detachable. The cylinder has a cast-iron liner, nickel-alloy valve seat inserts and separate valve guides.

A one-piece crankshaft and alloy connecting rod are employed, and the aluminium piston has two compression rings and an oil-control ring. Exhaust and inlet valves are of Silchrome steel, and are interchangeable. The cast-iron tappets are chilled, hardened and ground. Ignition is by Villiers high-voltage flywheel magneto. *Villiers Engineering Co. Ltd.*, Marston Road, Wolverhampton.

EMD 7221 for further information

Air Valve Silencer

It has been known for many years that prolonged exposure to high noise level in factories causes permanent and incurable loss of hearing. To help solve this problem, a range of silencers suitable for the complete range of pneumatic control valves manufactured by Martonair Ltd. has been developed. In addition, these silencers can be fitted to any other make of valve.



The silencers are made from Vyon, a porous plastics produced from high density polyethylene of medium pore size which is proving ideal for use as a filter or silencer on pneumatic equipment. It is said to effectively silence the noise from air valves without causing any loss of efficiency, and to be economical and robust. The silencers fit directly into the exhaust ports of the valves, and the exhausting air escapes to atmosphere through the porous plastics body. *Porous Plastics Ltd.*, Dagenham Dock, Essex.

EMD 7222 for further information

Ceramic Compressed Air Filters

A new compressed air filter, the F.101, has been designed for trouble-free operation of compressed air plant by a multi-stage cleaning action which is claimed to remove not only pipe scale and other solids, but also to free the air of unwanted oil, water droplets and mist.

The unit is designed for a maximum working pressure of 250 p.s.i.g., and has a capacity of 30 cu. ft./min., f.a.d., at 125 p.s.i.g. system pressure. The all-metal casing of lightweight aluminium alloy ensures its suitability for conditions where there is a possibility of solvent attack (for instance, in paint-spraying applications), and where possible rough usage demands a robust article.

A deflector on the inlet port gives the incoming dirty air an initial rotary movement before it passes through channels and passageways at the bottom end of a conical-shaped baffle. It is at this stage that the majority of the impurities are removed, the air being directed with a spiral spin against the inside wall of the casing. Some of the air is made to fan outwards, forming an air cone which effectively guards against any possibility of carry over or re-entrainment, and which causes the impurities to make their way downwards to the collecting zone beneath a plastics partition plate.

To undergo its final cleansing process the air passes through a porous ceramic filter element. There are, in fact, two filters available—a standard 30 micron grade which is considered entirely adequate for all normal purposes, and a 5 micron superfine grade to meet particularly stringent requirements. These ceramic filters, which are provided with plastics mounts moulded on to the ceramic, are manufactured by special techniques which give maximum efficiency and ensure that working pressure losses are kept as low as possible. *Doulton Industrial Porcelains Ltd.*, Wilnecote, Tamworth, Staffs.

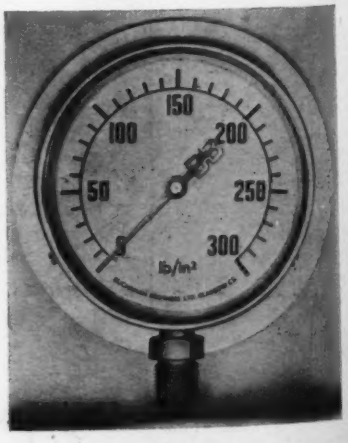
EMD 7223 for further information

Economy Pressure Gauge

The Clyde Economy Pressure Gauge is so-called because of its low price, which is the result of special quantity production techniques. This new gauge uses a tube with a conventional quadrant and pinion mechanism. The movement of the tube is transferred to the quadrant by means of a locating pin attached to the tube and moving within a slot in the tail of the quadrant.

The gauge has a flange back and a brass lacquer finish as standard. Block and dial screws are concealed, enhancing the external appearance of the instrument. A full range of British Standard Pressures from 60 to 600 p.s.i. are available, and the scale markings are of the Easiread type. The model just introduced is of 4 in. dial size; 2- and 2½-in. models will shortly be added to the range. *Buchanan Brothers Ltd.*, Commerce Street, Glasgow.

EMD 7224 for further information



Please Note!

We receive many reader enquiry cards on which the reader has omitted to fill in his name and address. In order to avoid disappointment we remind readers that names and addresses should be included on *each* card.

WHAT'S NEW IN COMPONENTS

Automatic Shut-down Valve

An automatic shut-down valve has been designed to act as a safety device in high pressure pneumatic or hydraulic systems. The valve shuts off the system whenever a minimum or maximum allowable pressure has been exceeded, or whenever there is a sudden pressure variation. Pressure variations such as these may be caused by pipe breakage, malfunctioning within the system, incorrect fitting to a fixing point or careless disconnection.

The valve has a maximum working pressure of 4,000 p.s.i (minimum 100 p.s.i.) and consists basically of a dome-like top chamber and a lower valve assembly. The dome is separated from the valve by a diaphragm which is sensitive to pressure variation and in direct contact with a poppet head valve. Variation in pressure differential across the diaphragm pushes the poppet head valve on to the valve seat, thus closing off the passageway through the valve. Closing time is about 0·7 sec. The valve can be re-opened again by means of a small by-pass valve built in the side of the body.

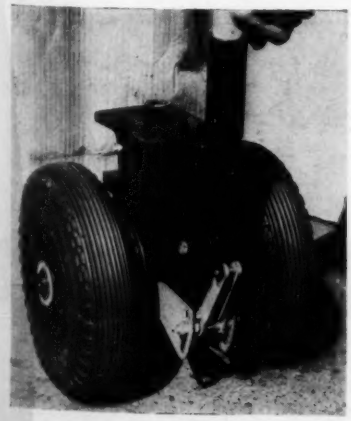
The valve weighs 1¼ lb., is 3 in. dia., and closes instantaneously when subjected to sudden surges. Its operating temperature range is from −10 to +66 deg. C. *I.V. Pressure Controllers Ltd.*, 683 London Road, Isleworth, Middlesex.

EMD 7225 for further information

Controlled Swivelling Wheel

This unit, with twin 10 in. dia. × 3 in. wide pneumatic-tyred wheels, has a dynamic load capacity of 10 cwt. The swivel comprises a malleable flange having sealed taper roller bearings mounted on a high-tensile pivot spindle. Each wheel has a 5 in. dia. internal expanding brake, and runs on roller bearings on a case-hardened and ground shaft. The brakes are automatically applied either on dropping the towbar to the ground or raising it to the vertical. Brake pressure is applied by spring, which obviates the possibility of damage to the mechanism. Two units of this type can be coupled for Ackerman steering.

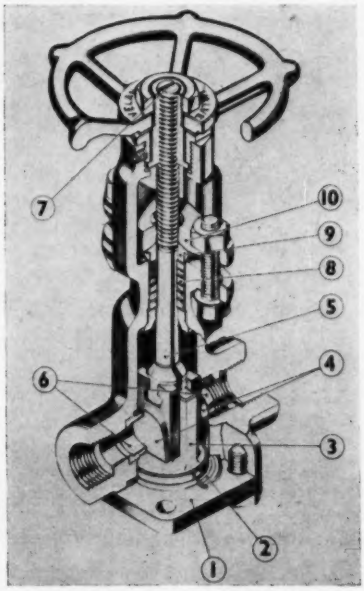
The unit is used in conjunction with two 16 × 4 in. pneumatic-tyred wheels. These are rubber mounted, and have a load capacity of 10 cwt. each. *Autoset (Production) Ltd.*, 69-73 Stour Street, Birmingham, 18.



EMD 7226 for further information

Gate and Globe Valves

The Newman-Velan valve can be tested and fully serviced while still connected in the pipeline. Both gate and globe types of forged-steel bonnetless design have "in-line" servicing facilities, and also incorporate other features aimed at reducing maintenance. The valves are said to cost little or no more, depending on the size and application, than conventional valves of comparable quality. All types are available with flanged, screwed or welded ends, and valves made from stainless steel or other materials for special services can be supplied.



The gate type shown here is available as inside or outside screw type, in a range of standard bore sizes from ¼ to 2 in. They are suitable for working pressures up to 600 p.s.i. at 480 deg.C. (2,000 p.s.i. cold, non-shock). The base of the valve *1* is formed by a bolted service cover sealed to the body by a stainless steel-asbestos gasket *2*. As this joint is not in any way affected by the operation of the valve and the body is a one-piece steel forging, there is virtually no possibility of leakage. Integral with the service cover are guide ribs *3* which ensure perfect guiding and alignment of the wedge *4* from closed to fully open position. A feature of this arrangement is that the cover, and with it the guide ribs, can be removed and cleaned (a new facility in gate valves) without the necessity for changing the body. *Newman, Hender Group*, Woodchester, near Stroud, Gloucestershire.

EMD 7227 for further information

One-piece Double-acting Fluid Seal

A fluid seal of symmetrical cross-section, for use in double-acting cylinders, is announced. It consists of two U-rings of equal size made from cotton or nylon fabric; these are bonded with a soft rubber filler to form a seal with inner and outer faces that are slightly convex. Distortion is said to be impossible, because there is no part where fluid might be trapped. The seal is supplied to fit pistons ranging from 1-7 in. dia. *Hall & Hall Ltd.*, Oldfield Works, Hampton, Middlesex.

EMD 7228 for further information

P.t.f.e. Pump

The working parts of a new pump are composed entirely of p.t.f.e., so it is expected that this unit will be particularly useful for pumping corrosive fluids, or liquids which must be protected from contaminating influences. It may therefore find a place for itself not only in chemical and other industrial processes, but also in the handling of certain liquid foods.

The new pump is a diaphragm type, and is self-priming. The vacuum-formed diaphragm, and all the other p.t.f.e. parts in contact with the liquid being pumped, are housed in a cast aluminium body which is bolted directly to a capacitor-run a.c. geared motor. The motor gearbox provides a 7:1 step-down to give a diaphragm reciprocation speed of 200 cycles/min. Life of the diaphragm is more than 1,000 hours.

Pump delivery at a 1-ft. head is said to be 2 litres/min., and at the maximum working head of 15 ft. to be 1·25 litres/min. Power consumption is 50 watts. The overall dimensions of motor and pump are: length 10 in., width 5 in. and height 5 in. Three models are available, to operate from 100/110, 200/220 and 230/250 volts, 50 c/s a.c. supplies. The inlet and outlet ports of the pump are supplied "belled" to accept a new ¾ in. A.E.I. p.t.f.e. pipe coupling. *Associated Electrical Industries Ltd.*, Crown House, Aldwych, London, W.C.2.

EMD 7229 for further information

FOR MORE INFORMATION
about any of the products mentioned on these pages, please use the special reply card bound in this issue.

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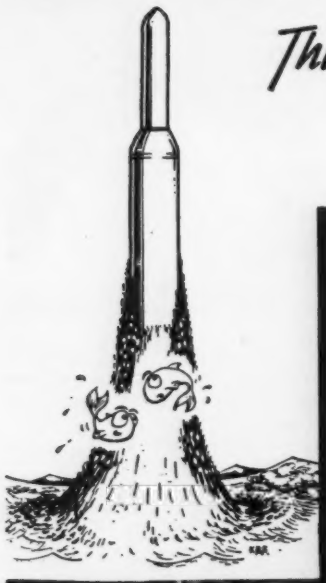

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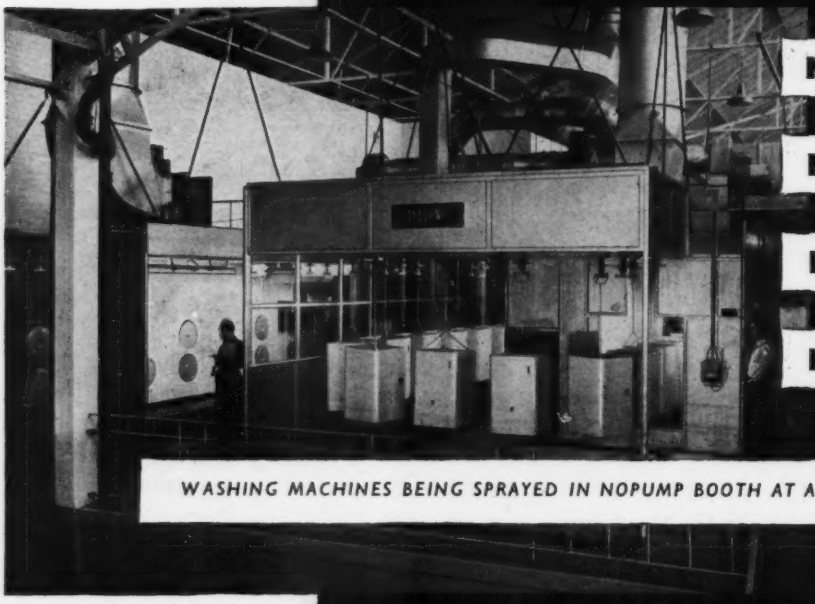
BULLOWS

NOPUMP SPRAY BOOTH

In this new type of Water-Wash Spray Booth the exhaust air travels at very high velocity over the water surface entraining water. The air/water mixture, moving through controlled changes of direction, provides the scrubbing action.



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NO PIPES

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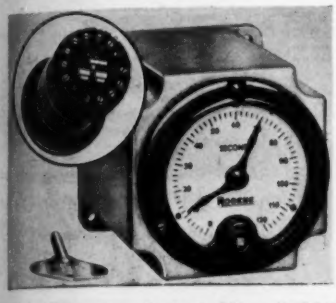
WHAT'S NEW IN COMPONENTS

Redesigned Timer

The type 7000 process timer has just been replaced by a new model, the Mark II. This is the result of a complete re-study



of the design, the principal object of which was to meet the growing need for very long life without loss of accuracy, even when used continuously, day and night, in tropical or other adverse environments.

The resultant changes include the use of new materials, such as alkyd for the contact actuators, and the replacement of the friction drive (usually fitted to prevent damage if the dial setting is altered while the timer is running) by a new free-wheel which picks up within a tenth of a degree and gives a solid forward drive.

The motor now has a larger coil wound on a moulded nylon bobbin, which raises the maximum voltage to 440. There is now a choice of ten ranges with full scale times of ¼, 1, 4, 12, 36 or 72 min. and 3, 12, 24 or 96 hr. The timer is available for flush or projection mounting, and the removable key can be provided as an alternative to a fixed setting knob.

The new moulded base allows bigger screw-type terminals in wire-retaining recesses, and gives better "creeps and jumps" figures. It also allows more connections to be brought out, thereby increasing the flexibility of use. For instance the clutch can now be fed from a separate d.c. source, to prevent resetting on mains failure or during breaks in an intermittent process. In the latter case, as the motor is the special instant-start Rodene type, the timer will accurately summate the running times. *D. Robinson & Co. Ltd.*, 717 London Road, Hounslow, Middlesex.

EMD 7230 for further information

Slip-ring Motors

A new range of slip-ring motors is announced: (1) continuous maximum rating with drip-proof enclosure up to 10 h.p. 4 pole speed, suitable for applications where the use of squirrel-cage motors is not practicable and for operation on 3-phase 50 c/s; (2) KRN class, suitable for use with cranes and lifts, ½ hr. or 1 hr. rated up to 15 h.p. 4 pole speed, with drip-proof or totally-enclosed endshields.

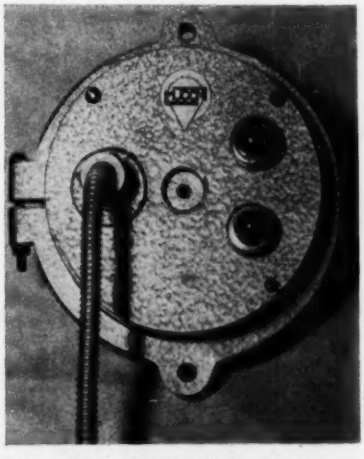
Both types of motor can be wound for voltages between 100 and 600 volts. Larger frame sizes are in production, carrying the range up to 30 h.p. and 40 h.p. All motors comply with BS 2613: 1957 for performance, and have fixing dimensions and shaft sizes as those standardised in BS 2960, Part 1: 1958 for the frame size used. The horse-power assigned to these frames is one step lower than the equivalent squirrel cage machine listed in BS 2960.

Other features of their construction are the inclusion of internal slip rings which give facilities for double shaft extension machines, and Class E insulation permits a 65 deg. C. temperature rise. The rings and brushes are continuously rated; special attention has been paid to the design to allow easier accessibility to slip ring and brush gear assemblies for maintenance purposes. *Crompton Parkinson Ltd.*, Crompton House, Aldwych, W.C.2.

EMD 7231 for further information

Hopper Level Switch

This device is an automatic hopper level control switch for solids and slurries, and is particularly suitable for light powders



and products of low bulk density. It comprises an aluminium alloy body measuring 5 in. dia. and 2¾ in. deep, and has a separate fixing clamp and two compartments separated by a stout partition. This serves the dual purpose of protecting the diaphragm against overloading, and of preventing the contents of the hopper entering the electrical compartment in the event of diaphragm failure.

The replaceable steel or plastics sheet diaphragm can be supplied with various coverings when necessary. Sensitivity can be externally adjusted, and deflection of the diaphragm is directly transmitted to a micro-switch. Plug or conduit entry can be provided, and the switch may be connected for local indication, remote signal, motor control switching or bin stock control.

The switch is said to be easy to install, requiring only a 5 in. dia. hole in the hopper wall, a fixing clamp, sealing ring and two bolts. By adjusting the clamping screw, the diaphragm can be placed in the best position relative to the material in the hopper. *Mucon Engineering Co. Ltd.*, Ruislip, Middlesex.

EMD 7232 for further information

Pneumatic Time Delay Relay

This new relay, designated Class 9050 Type A, is an evolution from the Class 8501 Type D relay. The timing period is adjustable from 0·2 sec. to 1 min. with good repeat accuracy. Normal variations in voltages and temperatures are said to have little effect upon the time accuracy because of the principles upon which the timing action is based. An unusual feature is the closed air circuit, which prevents the ingress of foreign matter into the pneumatic system and thus ensures reliability.

Timers are available with time delay after energisation of magnet coil, or time delay after de-energisation of magnet coil. Either type of relay can be converted to the other without the use of additional parts. *Square D Ltd.*, Cheney Manor, Swindon, Wilts.

EMD 7233 for further information

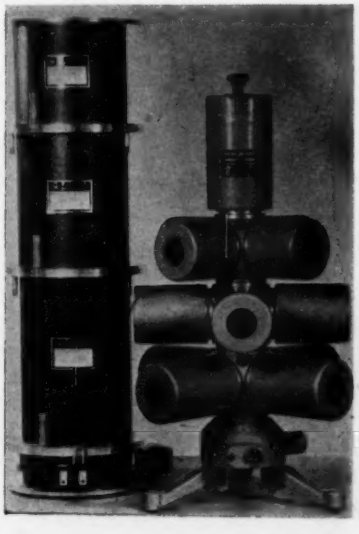
Switch-less Capacitance Standards

A wide range of switch-less capacitance standards have been introduced into the U.K. The availability of a high-grade capacitance standard of wide range makes possible the use of accurate capacity measurements by simple substitution and inductance measurement by resonance methods at standard frequencies.

The Jahre system uses five- and six-sided connector blocks (Dice connectors) and plug-in units to give combinations of 1-2-3-4, adding up from 10 pf. to 10 mf., in 10 pf. increments.

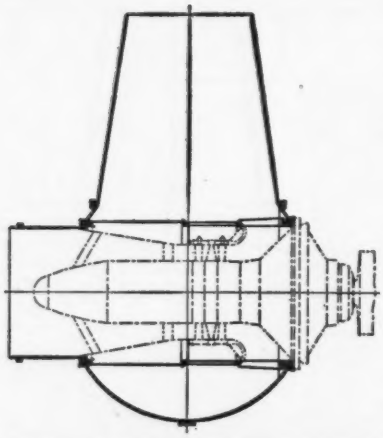
The novel "Xmas tree" assembly is said to have proved easy and rapid in laboratory use, occupying little bench space. Unused ports on the connector blocks are covered by screening caps, while the capacitor units are stored in polished wood racks. The rigid construction ensures stability of the standards with normal care in handling without "cotton-wool and glass case" treatment. Variable capacitors provide continuous coverage of 16 or 70 pf., with discrimination of 0·01 and 0·1 pf. respectively. *Aveley Electric Ltd.*, Ayron Road, Aveley Industrial Estate, South Ockendon, Essex.

EMD 7234 for further information



EMD 7153 for further information

New thinking for Trawsfynydd

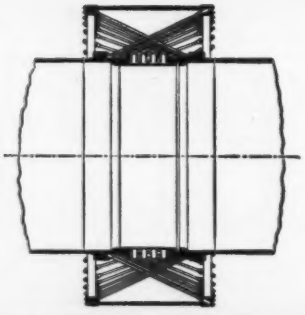


CO_2 CIRCULATORS

As every engineer knows, the thickness of plate required to contain a given pressure is halved if the vessel is spherical instead of cylindrical. It is odd—but nevertheless true—that it was not until our own engineers were confronted with the design of the CO_2 circulatory system for Trawsfynydd that the elementary principle was put into practice on large pressure pipework.
Besides halving the plate thickness spherical construction has other advantages. All welds are circular, can be prepared by machinery and are simple to X-ray.

CORNER BENDS

The same advantages follow when the same principle is applied to corner bends. In addition, the stiffeners required on cylindrical bends are eliminated. Internal tubes—not subject to pressure—provide a smooth gas flow.



EXPANSION JOINTS

It is standard practice to take up the expansion of large diameter pipework by flexing at what are essentially hinged joints. These of course have to provide restraint against axial forces—over 1,000,000 lb. in the Trawsfynydd ducting. The usual solutions, an internal metal tongue or a hinged joint are heavy, cumbersome and, moreover, flexible in one direction only. The hinge we have devised is flexible in *all* directions, by elastic straining of the high-tensile steel, restraining rods. The circumferential pressure is taken by a metal bellows, faired internally by a floating sleeve.

These ideas are not our only contribution to Trawsfynydd. As well as the complete CO_2 circulation system, we are building the whole of the generating plant, comprising steam turbo-alternators, condensing plant and feed heating systems.

RICHARDSONS, WESTGARTH & CO LTD

The Controlling Company of the RICHARDSONS WESTGARTH GROUP, Wallsend, Northumberland, and 58 Victoria Street, London, S.W.1

ASSOCIATED COMPANY: ATOMIC POWER CONSTRUCTIONS LTD.

RW 74

WHAT'S NEW IN THE OFFICE

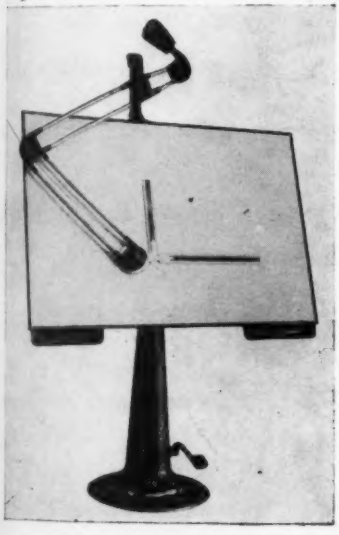
Backing Sheets

Rembroplast is a special laminated plastics material which provides a working surface for tracing paper or tracing cloth. Particular features claimed for it are: (a) it is flexible to the pressure of hard pencils, so that no indentations are produced and a smooth surface is always provided; (b) its light green or off white coloured surface reduces glare; (c) it always lies flat on the drawing board and is easily cleaned with any eraser or detergent; and (d) needle point holes made in it are almost self-sealing. *B. Charles Roff & Co. Ltd.*, 38A Paradise Street, Birmingham, 1.

EMD 7235 for further information

Lower Drafting Stand

The Nike drafting stand is now available with a board height (horizontal) of approximately 2 ft. 6 in. The trend over the past two or three years has been for draftsmen and architects to work at a lower height than previously, and it is to meet this need that this lower stand has been introduced. Its overall design and



mechanism is identical to the original Nike stand, which is still available, but in a slightly smaller size. *M.B.C. (Office Systems) Ltd.*, 31 Crouch Street, Colchester.

EMD 7236 for further information

Fluorescent Set Square

Of interest at the Drawing Office Equipment and Materials Exhibition was a fluorescent set square, which due to the extremely bright edge caused by the fluorescence, is claimed to eliminate any shadow along the edge. It is supplied made in ⅛ in. fluorescent perspex, in all the usual sizes, and has been accepted for inclusion in the Design Index of the Council of Industrial Design. *Unique Slide Rule Co. Ltd.*, Buckhurst Road, Telscombe Cliffs, Newhaven.

EMD 7237 for further information

Automatic Stapling Machine

The Electrostapler is believed to be the first British designed and constructed fully-electric machine for stapling. It leaves both hands free for manipulating the work, and gives a fastening rate of hundreds per hour without stress or fatigue.

Complete safety is ensured, since the electrical circuit is automatically cut out whenever the cover is raised for reloading, which is carried out by feed-slide from the front. There is a side screw for adjusting the position in which staples are fixed. The two finishes available are grey stoved enamel, and chromium. *Ofrex Ltd.*, Ofrex House, Stephen Street, London, W.1.

EMD 7238 for further information

Pencils for the Draftsman

Mechanical pencils of advanced style to meet the exacting requirements of the draftsman, architect, layout man, etc., are now available. The lead has a thickness of 2 mm., so that either chisel-pointing or normal pointing can be used. Length of lead is 5 in., and a dozen degrees of hardness are available, each lead being marked at the base according to grade. The range is from 4B to 6H (including F) in black graphite, and red, blue, green, magenta and purple in copying colour, medium grade.

Draftsmen require a perfectly rigid point entirely free from wobble, and this is secured in these pencils by a unique chuck action which grips the refill lead right down to the last ¼ in. Uniformity and consistency of graduation is a special feature, and the graphite has an even and silky flow. Refilling or changing lead is simple and quick, being achieved by simply pressing on the top of the pencil, thus releasing the lead by gravity. For normal pointing the detachable top knob on the pencil contains four small blades which trim the point of the lead when required.

The pencils are supplied in desk sets of pressed plastics, each containing six pencils marked all round the barrel with the grade of lead which they contain. The sets are made up as follows: No. 345/1, one pencil each grades H to 6H; No. 345/2, one pencil each grades F to 4B; Set No. 354/3, six pencils assorted to individual requirements in black or colours. *Ofrex Ltd.*, Ofrex House, Stephen Street, London, W.1.

EMD 7239 for further information

Filing System for Small Drawings

The Elite system for small drawings is based on an entirely new principle. Each file bar holds up to 225 drawings (sheet size 20 × 15 in.), and up to eight file bars are fitted per drawer, providing a total capacity of up to 5,400 drawings. Any one drawing may be extracted almost instantly. A lever on the right of the drawer is moved to the vertical position and the drawings are automatically extended from 2 to 4½ in. Thus selection of any one drawing is easy. By moving the lever forward the file bar is "broken", and the required drawing may be removed. The file bar closes with a slam action.

The Elite system offers drawing protection, space saving (5,400 sheets in 25 × 25 in.), and ease of operation. *M.B.C. (Office Systems) Ltd.*, 31 Crouch Street, Colchester.

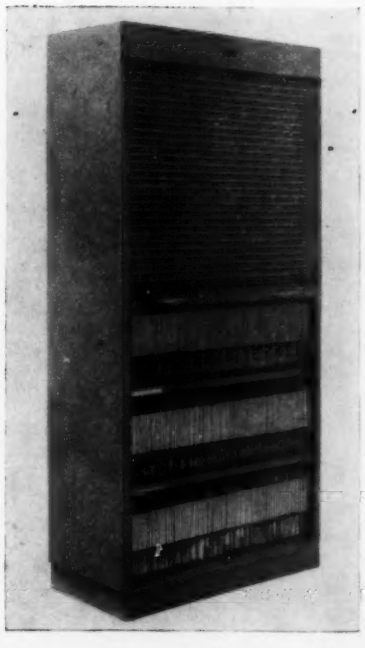
EMD 7240 for further information

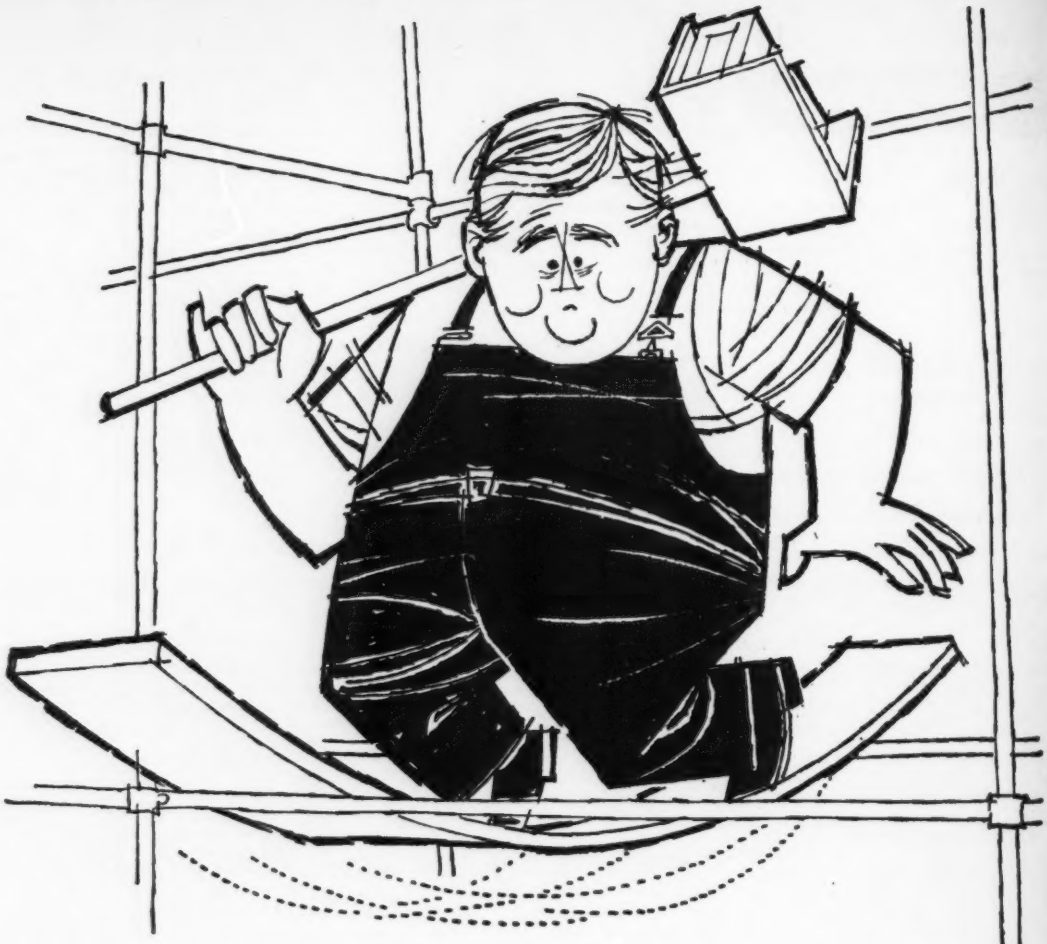
Lateral Filing Unit

This is available in five- and six-row units, each row accommodating between fifty and seventy-five suspended lateral pockets linked at the top and complete with metal title-strip holders on the leading edge of the folder. The dimensions of the units are as follows: five row—76 in. high × 36 in. wide × 18 in. deep; and six row—89 in. high × 36 in. wide × 18 in. deep.

The units are available with: (a) open fronts; (b) linen blinds; or (c) steel roller shutters fitted with lock in standard finishes of either olive green or warm grey. All units are fitted with removable side panels, thus enabling them to be installed in runs and bolted together with an end panel at each end of the run. *Leabank Office Equipment Ltd.*, Clifton House, 91 Euston Road, London, N.W.1.

EMD 7241 for further information





prolonging the moment!

His only support is bending beneath him
and he feels he'll soon be leaving the
world of δ max = $Wl^3/4Ebd^3$. Too late now
to remember that the thicker the beam section
the greater by the power of three
its moment of inertia. The only thing to do
is bequeath this truth to posterity:
magnesium increases strength and stiffness
without weight penalty. The lightest
structural metal for rectangular and
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WHAT'S NEW IN EQUIPMENT

New Drying Cabinet

A new standard hot-air drying cabinet has been introduced, designed for drying off light components after plating, phosphating or similar processing operations. The unit is electrically heated with a rating of 10 kW. and is suitable for wiring into a 400/440 volts, 50 c/s, 3 phase a.c. supply. It is thermostatically controlled for an operating temperature of 82 to 93 deg. C., and the electrical switchgear incorporates a motor starter, fuse board, contactor and main isolation switch fuse unit.

The cabinet is 5 ft. 11 in. high × 3 ft. 6 in. wide × 2 ft. 6 in. front to back, and incorporates two sliding drawers 2 ft. 9 in. wide × 2 ft. long by 1 ft. 3 in. high.

Air is circulated over the components by a propellor fan driven by a ½ h.p. motor. The electrical circuit is designed so that the fan commences to operate before the heater circuit is energised. *A. E. Griffiths (Smethwick) Ltd.*, Booth Street, Handsworth, Birmingham, 21.

EMD 7242 for further information

Paint Film Holiday Detector

The Mapel holiday detector has been developed for thin paint films. This instrument can accurately determine pin holes, voids or bare spots in a surface coating with a very high electrical resistance when such material is brushed or spread onto an electrically conductive surface such as steel or concrete.

The Mapel is not a spark detector, and is non-destructive. The applied voltage never exceeds 70 volts at any time. A flat sponge electrode measuring ½ × 6 in. damped with clear water is the inspection electrode. When a fault is encountered in the paint film a small current leaks from the dry cell batteries and signals the presence of the fault by sounding a buzzer in the detector, and by giving a visual light indication on the unit. The design of the sponge electrode makes it possible to penetrate orifices and edges (where holidays are most likely to occur). Full inspection is ensured, because the wet sponge provides a continuous liquid film over the coated area.

The whole unit is light in weight, and can be easily held in one hand. Two models are available, one with a pistol grip handle, and the other with a belt attachment which will not hamper the operator's activity on high structures. *Metal & Pipeline Endurance Ltd.*, Woolmer Green, Knebworth, Herts.

EMD 7243 for further information

Stripping Tool for Plastics-covered Wire

A new stripping tool for plastics-covered wires is now available. As can be seen from the accompanying illustration, it is a hand tool with an electric element (for clarity, the anvils are shown "open"). An outstanding feature is ease and speed of use by untrained operators without danger of damage to the conductors. In use, the spring-loaded trigger is depressed with the thumb, the wire positioned in the anvils, the trigger released, and a slight twist of the wrist pulls the insulation off. The tool weighs 6 oz. (without cable), and is supplied with 2 yd. p.c.p. grease-resistant cable. Elements can be produced to suit all voltages. *Lyteze Products Ltd.*, 90 Church Road, Brightlingsea, Essex.

EMD 7244 for further information

New Dexion Cutter

The new Dexion Mark V cutter has been introduced for sale in the U.K. This cutter requires no assembly—it can be used straight from its container, on bench or floor—and is readily portable. Cutting is just a matter of feeding in the Dexion Angle and pressing down the handle.

The new cutter works on the guillotine principle, giving longer blade life and enabling diagonals to be cut more easily than before. By using this tool rather than a hacksaw, a clean cut is said to be achieved every time. *Dexion Group*, Maygrove Road, London, N.W.6.

EMD 7245 for further information

New Publications and Technical Literature

Dunlop Rubber Co. Ltd.: "Engineering in Rubber", a 15-page reprint of a lecture given to the Manchester Association of Engineers by D. H. Cooper. Education Section, 10-12 King Street, London, S.W.1.

EMD 7246

Avica Equipment Ltd.: Leaflet of data on Avica-Flex gimbal-type flexible joints and bellows assemblies. Mark Road, Hemel Hempstead, Herts.

EMD 7247

Air Automation: 25-page illustrated catalogue of the firm's air control valves and cylinders, pneumatic vices, blow guns and airline equipment. 26 Sharrocks Street, Wolverhampton, Staffs.

EMD 7248

Clayton Dewandre Co. Ltd.: Four leaflets on Clayton-Still wire-wound heat-transfer tube: "Oil and Air"; "Water and Oil"; "Water and Gases"; and "Refrigeration". P.O. Box 9, Titanic Works, Lincoln.

EMD 7249

London Metal Warehouses Ltd.: 10-page pocket reference chart on aluminium and its alloys. Summer Road, Thames Ditton, Surrey.

EMD 7250

Copper Development Association: 30-page booklet of data on copper-bearing steels for structural purposes. 55 South Audley Street, London, W.1.

EMD 7251

Taylor Bros. & Co. Ltd.: 16-page brochure of illustrations describing the manufacture of the firm's range of rings and circular die forgings. Trafford Park Steel Works, Manchester, 17.

EMD 7252

Mandoval Ltd.: 40-page illustrated handbook on vermiculite and its applications in the building and many other industries. This material is used for insulation and fire protection. 59 Gresham Street, London, E.C.2.

EMD 7253

Irish Ropes Ltd.: 5-page leaflet giving details of a newly developed chemically bound chopped strand Sisal mat, and its use in reinforced plastics. Newbridge (Droichead-Nua), Co. Kildare, Ireland.

EMD 7254

Belling & Lee Ltd.: 11-page leaflet on Prestincert, which is a method of mounting components of all kinds on panels, chassis, die castings, etc., or of riveting laminae together with no preparatory punching or drilling operations. Great Cambridge Road, Enfield, Middlesex.

EMD 7255

The Gauge and Tool Makers' Association: "Handbook and Buyers' Guide Index (eighth edition)", summarising the aims, objects and activities of the Association, and giving the names, addresses, telephone numbers, and telegraphic addresses of the present 386 member-companies. Standbrook House, 2-5 Old Bond Street, London, W.1.

EMD 7256

EMD 7155 for further information

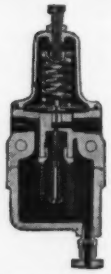
INDUSTRY WELCOMES THE NEW TECALEMIT RIBBON FILTER ELEMENTS

Setting a fresh standard of high efficiency filtration for

AIR–WATER–PETROL DIESEL AND FUEL OILS | LUBRICATING, HYDRAULIC AND OTHER FLUIDS

Chosen for the famous FISHER small volume regulators

Tecalemit Ribbon Filter Element is used in the series 67 combination Filter Regulator, manufactured by Fisher Governor Company Limited of Rochester. In such an application, the paper ribbon filter allows air to flow freely and provide adequate filtration, and water separation. A Tecalemit ribbon filter is sufficiently robust to withstand pressure drops well in excess of normal working conditions.



Tecalemit Ribbon Filter Elements

Simple construction—Low cost—High flow rate—Easy to clean

The elements are formed to resin impregnated cellulose ribbon, wound helically and electrically fused into an open-ended cylinder. Innumerable microscopic orifices between the ribbons allow a very high flow rate, while retaining impurities on the outside or inside surfaces, according to direction of flow. The standard range of diameters (in any length) covers most applications, and no other filtration material can so readily be adapted to individual requirements for filters, strainers, breathers or separators. Never before has such fine filtration been possible at such low cost and with such flexibility in use.

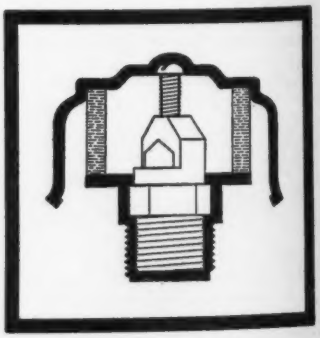
Tecalemit Ribbon Elements filter to maximum purity

Tecalemit Air Breather Filters

(Incorporating Tecalemit Ribbon Filter Elements)

Cheapest—most efficient—cleanest to service Tecalemit Breathers act as ventilators to provide a free flow of clean air to hydraulic fluid, fuel and oil reservoirs. They give positive protection from airborne contamination to tanks, pumps, valves, cylinder and other engine components. Of the standard types, two are breathers with screwed bodies, and the third is a combined clip-on assembly of breather and filter cap. All are fitted with Tecalemit Ribbon Filter Elements.

Tecalemit Breathers provide pure air cheaply and efficiently



TECALEMIT the authority on filtration

TECALEMIT LIMITED · (SALES EMD) · PLYMOUTH · DEVON

T. 798

NEWS OF INDUSTRY

The recent launching of a 48 ft. auxiliary sailing cruiser is an example of successful co-operation between shipbuilders and resin manufacturers. Structural plastics are being used in the construction of a varied range of boats, including the *Glass Slipper*, which is one of the largest resin-glass sloops in the world. **B.I.P. Chemicals** Beetle polyester resins, and **Turners** Duraglas reinforcing, have been used to produce a seaworthy vessel with a very high strength/weight ratio. This design, with buoyancy compartments, provision and water tanks integrated with the hull, gives great strength.

The *Glass Slipper* was built by the **Tyler Boat Co. Ltd.**, and the method of construction is based on the company's considerable experience in handling resin-glass laminates—great rigidity has been combined with light weight and economic use of material. After laying up the outer skin of the hull and incorporating the web frames and bulkheads, a layer of rigid polyurethane foam was sprayed onto the inside of the skin. This foam layer is about 1 in. thick, and a second thinner layer of resin-glass is laminated over it, forming a sandwich with a lightweight core.

Delaney Gallay Ltd. are at present expanding their works facilities to increase capacity, and also their laboratories to deal with the joining problems associated with "newer" metals which are likely to be in common use in the near future. This company has considerable experience in the joining of metals, and may be regarded as experts in all commercially useful methods of brazing and welding. In particular, they can offer flux bath facilities for light alloys, and vacuum furnace facilities for heat-resisting alloys.

The flux bath is especially valuable for the joining of very light gauge metal where inaccessible joints are required, and where distortion must be kept within very narrow limits. The vacuum furnace, which is one of the largest in the world, has been designed specifically for the brazing and heat-treatment of stainless steel, high nickel-chromium-cobalt alloys, and other metals where a tenacious refractory film is present at the surface.

United States Rubber Co., who have developed collapsible rubber containers called Sealdrums, are making test shipments of latex in rubber drums from their plantations in Malaya. Each Sealdrum holds 500 gallons of latex (most of it a general-purpose type), which will be used to make such items as adhesives, non-skid carpet backing and household gloves.

In the normal way latex is shipped in disposable steel drums, or in 150,000 gallon tanks found only on specially equipped vessels. The new rubber drums permit more flexible shipment schedules, because they can be carried on almost any type of vessel. The drums are easy to clean, and are said to prevent contamination of the air-sensitive latex. After being emptied they occupy little storage space.

Johnson Matthey & Co. Ltd. announce that zone-refined 50 ohm-cm. n-type germanium is now available, normally in ingots having a nominal weight of 1 kg. A large scrap recovery plant has been installed which enables a wide variety of types of germanium-bearing residue to be processed. The company now wishes to purchase large or small quantities of germanium scrap.

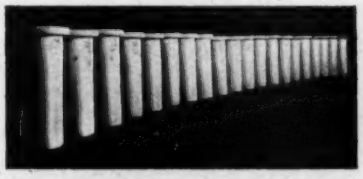
Hawker Siddeley Aviation Ltd. are to endow a readership and lectureship in noise and vibration research at the **University of Southampton.** The aeronautical engineering department of the University, under Professor E. J. Richards, has specialised in research associated with noise and vibration, specifically in relation to aircraft, land vehicles and ships; an article on this by a member of the staff was published in *Engineering Materials & Design* in April and May 1959.

The department is receiving support for this type of research from many sources, including the U.S. Air Force, and it is intended to establish a Master of Science course to extend the research in these subjects. The first course is planned to start in October, and the University will also offer short courses in acoustic subjects. Present work being done includes the study of structural fatigue due to noise, and the Department has become the recognised leader in this field of research.

In the production of high quality strip the **British Aluminium Co.** have successfully adopted two **Turners Poly-V** Drives in place of the earlier reduction gears. The introduction of the Poly-V Drive has not only resulted in an improved product quality by the smooth transmission of power, but has also reduced the noise level of the mill, with considerable benefit to the operators.

Walter Landor, one of the 1961 Alcoa Industrial Design Award winners, shown with the transceiver he designed for Kaar Engineering Corp. Housed in an interlocking case formed from aluminium sheet, the two-way radio gains increased efficiency through the use of this metal.

Filtration of active chemicals, used to separate plutonium fission products and uranium by solvent extraction, is a particularly exacting task for equipment, and it is essential to employ a material which is mechanically strong, chemically inert and has a large volume flow with a low pressure drop. For this purpose Vyon is being supplied to the U.K. Atomic Energy Authority in the form of filter candles, to protect pump valve packs and other



equipment in the liquid chemical feedlines. Vyon is a porous plastic produced from high density polyethylene of the Ziegler type, and is manufactured by **Porous Plastics Ltd.** Since it is completely free from detachable fibres, it is an ideal filter material.

EXHIBITIONS AND MEETINGS

The **Joint British Committee for Stress Analysis** is organising the second international Conference on stress analysis in Paris, from April 10 to 14, 1962. Contributions will deal mainly with the results of experimental work, and prospective authors are invited to write to the secretary for information on the preparation of papers.

The Division of Metal Science at **Borough Polytechnic** have arranged four special lecture courses for the 1961-62 winter session, the first one being scheduled for October 4. These courses are entitled: "Modern Developments in Non-destructive Testing of Metals"; "Refractories, their Manufacture, Properties and Uses"; "Recent Advances in Semiconductor Metallurgy"; and "Corrosion and Protection of Buried Metal".

FILMS

Two new films by **Shell International Petroleum Co. Ltd.** are entitled **The Free Piston Engine,** and **A Question of Springing.** The first describes the free piston engine, and shows how it combines the working principles of the two-stroke diesel and the gas turbine. The film is in colour, 35 and 16 mm., and runs for 18 min.

The second film is Part 3 of "How the Motor Car Works", and is a light-hearted approach using animation to explain complex systems of suspension. It is in colour, 35 or 16 mm., and runs for 18 min.

Computer Achievements, a new E.M.I. 22-min. 16-mm. film in colour and sound, features five of the many varied uses for which Emidec computers are being supplied to leading industrial organisations.

EMD 7156 for further information

"STRATELINE"

SPEED REDUCING

Input H.P. range 1/16th to 40 H.P.
Ratios from 3:1 to 1,000,000:1

Greater reductions can be undertaken for special applications.

Maximum torque output 100,000 lbs ins.

Coaxial Shafts: Positive gear drive therefore no slip.

Large Reduction Ratios in very small space.

Each unit covering a wide range of ratios without alteration to external dimension.

Can be supplied with an electric motor as an integral part of the gear box, or as a non-motorised unit.

Units can be arranged for any position of mounting.

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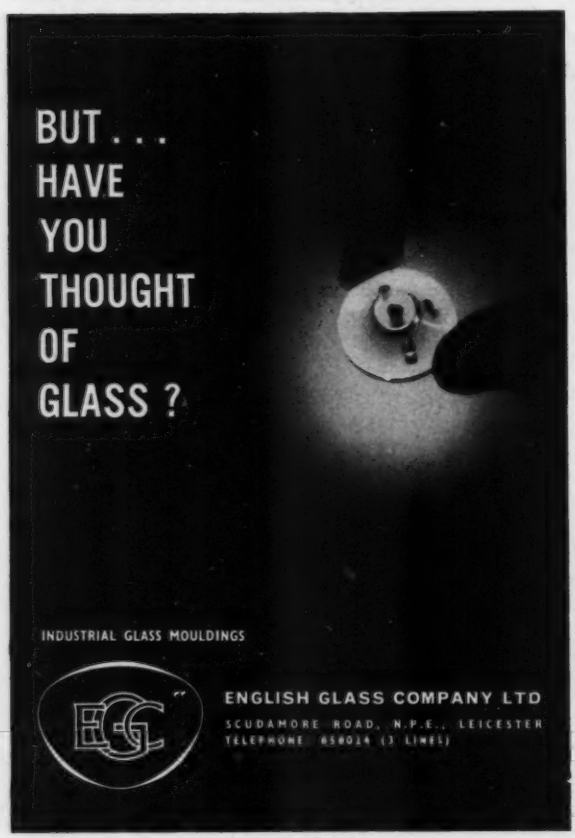

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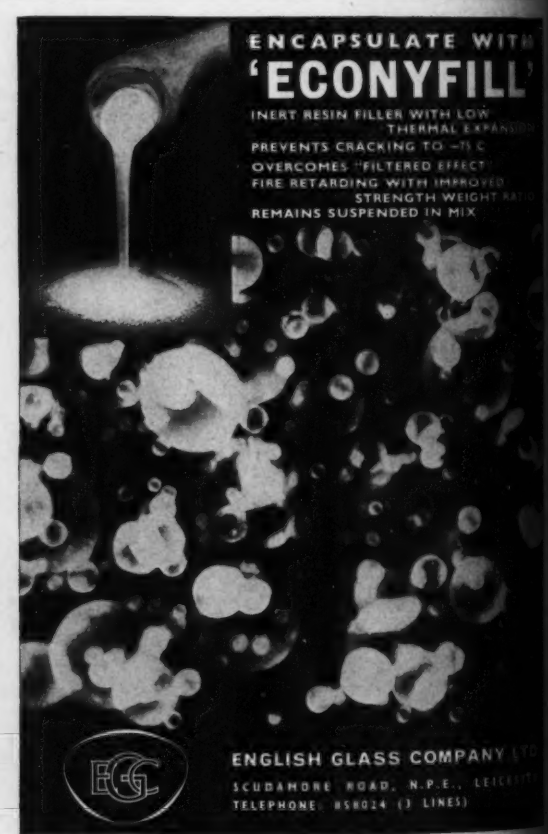
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